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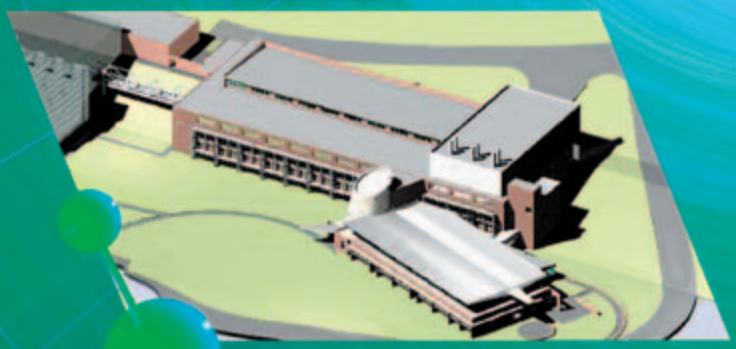
NREL National Renewable Energy Laboratory

National Renewable Energy Laboratory
Self-Assessment Report
April through September, 2003



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National Renewable Energy Laboratory Self-Assessment Report
(April 1 – September. 30, 2003)

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Executive Summary

The National Renewable Energy Laboratory, under the stewardship of MRI and its integrated team of Battelle and Bechtel, successfully met or exceeded performance expectations across each Critical Outcome. Highlights include:

- Outstanding science and technology (S&T) accomplishments fully enabled by high quality RD&D
- Exceptional program planning, management and integration
- Effective communication and outreach
- Agile business support and infrastructure management
- Proactive leadership demonstrated across all aspects of the business

In serving the needs of EERE and the nation, NREL proactively and effectively responded to emerging challenges and opportunities while exceeding expectations across its six Critical Outcomes. At the foundation of NREL's progress was strong collaboration and cooperation with EERE and GO.

Based on the results detailed in this Self-Assessment Report, NREL proposes an overall Laboratory performance rating of ***Outstanding***.

CO 1.0 Science and Technology

Expectations for innovation, quality, and impact, along with a supportive work environment established by MRI and its integrated management team enables NREL to produce relevant, high-quality S&T outcomes.

The Laboratory's continued outstanding track record in producing relevant, high-quality science and technological outcomes is evidenced at both the institution and individual level by:

- NREL's increasing role in providing technical advice and supporting development of integrated, DOE multi-year RD&D plans
- Advances in S&T that support DOE objectives
- Adoption and use of NREL-originated technology and knowledge by others.

NREL and its staff received considerable external recognition for S&T excellence in innovation, relevance and quality of the work, technology transfer, and mentoring. Awards included an R&D 100 award, an Institutional Federal Laboratory Consortium (FLC) Award for NREL's long-term commitment to expanding the use of renewables, and a DOE Outstanding Mentor award. Peer reviews of NREL's work acknowledged its quality and relevance and provided useful feedback on potential future directions. Numerous invitations to speak, lecture, publish, or chair conferences recognized NREL as a valued source of intellectual leadership.

While delivering on program commitments, the Laboratory played an increasingly significant role in DOE multi-year technical plans and integrated FY04 annual operating plan development. The enhanced role of NREL as a technical adviser and strategic partner in planning yielded high-quality technical plans, such as the multi-year RD&D plan for the Hydrogen, Fuel Cell, and Infrastructure Technologies (HFCIT) program that was well received by the National Research Council. The roles that NREL played in supporting DOE planning enabled the strong alignment of NREL efforts with the objectives of those plans. NREL's maturing systems-based analytical capabilities provided value to DOE planning by validating program technical targets, such as the preliminary system and component level targets for heavy hybrid vehicles under the FreedomCAR and Vehicle Technologies Program. In several cases, such as in the Biomass Program, NREL supported DOE by serving as the technical integrator among the laboratories and other program participants to ensure that individual efforts are aligned and support overall program goals.

S&T advances lower costs and/or increase reliability of DOE-supported technologies or reduce barriers to their use. Key S&T accomplishments furthering DOE program goals, were made in every program. Examples include;

- Demonstrating bench-scale production of hydrogen from waste plastic
- Significantly exceeding the cellulose enzymes target cost reduction
- Receiving final approval of the distributed generation interconnection standards
- Validating the efficacy of energy-efficient liquid desiccant technology to deactivate anthrax spores using MRI's certified biosafety laboratories
- Increasing solar cell efficiencies
- Advancing the understanding of nocturnal low-level jet streams in order to understand the potential impact on low wind speed turbine designs

MRI and its integrated team continued to steward knowledge and technology from creation through its transfer to others via a record number of publications, technical assistance to domestic government agencies and international organizations, and through a variety of partnerships with the commercial sector.

NREL technical assistance enabled the federal government to increase its use of renewables to more than 50% of its 2005 goal by yearend through the Federal Energy Management Program. The Laboratory formed three strategic industrial partnerships under the Biomass program that will advance program goals and transfer NREL-originated intellectual property for commercial use. The National Alliance of Clean Energy Business Incubators now supports 80 companies that have created nearly 1,000 jobs. The growing recognition of NREL as a player in the technology transfer community was acknowledged by the FLC award mentioned earlier, and by its growing impact within the DOE Technology Partnerships Working Group. Additionally, NREL took the lead in developing an intellectual property framework that enabled partnering in a proposed virtual hydrogen storage center among seven universities, three federal laboratories, and an industrial company.

Based on its continued record of innovation, quality, and impact, NREL proposes a rating of ***Outstanding*** for the Science and Technology Critical Outcome.

CO 2.0 Leadership

By advancing new concepts, providing fresh insight through analyses, and by providing expert knowledge in key forums, NREL has influenced the direction of DOE program strategies and national policy and programs.

MRI and its integrated team of Battelle and Bechtel provide leadership to strengthen NREL's role as a Federally Funded Research and Development Center (FFRDC) - supporting the EERE mission.

Laboratory leadership and corporate support defined and launched the systems integration role for the DOE Hydrogen Program. Working closely with DOE, NREL laid the groundwork to establish the capability and began development of an integrated baseline. The search for a Systems Integration director has yielded several quality candidates and NREL expects to have the director in place in the first quarter of FY04. Development of the first Systems Integration plan enabled positive interactions with key external stakeholders, such as the National Research Council and the FreedomCAR and Fuel Partnership.

NREL leadership in strategic analyses provided a basis for exploring the feasibility of new initiatives, such as a potential solar initiative, and for making program and policy decisions. Multiple analyses conducted for the HFCIT and FreedomCAR and Vehicle Technologies programs led to fuel cell and hydrogen storage target revisions, and illuminated the fuel consumption penalty associated with cold starts on reformed gasoline fuel cell vehicles that will inform the 2004 go/no go decision. NREL analysis also informed stakeholder choices among technology options. Through NREL's air quality initiative, analyses are informing EPA, state and local environmental policy and program decisions, and analyses of the solar resource and use of NREL-developed system analysis tools have supported SolarGenix in developing a proposed 50MW$_e$ CSP plant to generate enough electricity in 2005 - 2006 to comply with the solar portion of the Nevada renewable energy portfolio standard.

NREL provided technical leadership in defining a diverse set of new opportunities and future directions. The Lab catalyzed and co-wrote a multi-laboratory white paper that proposes how to integrate and use the technical resources of the national laboratories to advance the goals of the Solid State Lighting initiative. NREL led development of a vehicle power electronics roadmap

that will serve as a guide for future multi-year RD&D plans. NREL worked with the regional offices and with other labs to develop a collaborative state technical assistance program to be delivered through regional offices, and worked with DOE, other agencies, and NGOs to develop an African clean energy initiative.

By convening or providing leadership in key forums, NREL had an influence in establishing national directions in key areas that advanced EERE program objectives. An NREL-organized summit led to the blueprint development for domestic hydrogen codes and standards; a joint meeting between the Wind and Hydropower and the HFCIT programs, including industry and key stakeholders, created an understanding of opportunities and demonstrated the program commitment to including these resources in its long-term plans; and NREL technical leadership in multiple International Energy Agency agreements on behalf of DOE programs continued to favorably position the United States as a leader in key areas such as hydrogen and renewable energy.

NREL led the development and implementation of multiple strategic partnerships that leverage resources and advance DOE program priorities. Included among these was the development of a strong team to implement a proposed virtual Carbon-based Hydrogen Storage Center. The significant number of white papers submitted by potential participants is an indicator of the strong interest in teaming under NREL's leadership in this center. The award of a major Office of Science nanoscience project to NREL provides resources in an area of science that will underpin future advances in photovoltaics. The selection of this proposal through a competitive, peer-reviewed process is an indicator of NREL's technical leadership in nanoscience. The development of a five-year CRADA valued at $7M, with AVL, licensee for the ADVISOR™ model, will improve the capabilities of the model and extend its value to DOE and other users.

A rating of ***Outstanding*** for Critical Outcome 2.0 Leadership is proposed, based on the broad and diverse examples of NREL's leadership in creating new opportunities and partnerships, and in influencing program and policy directions through its technical and analytical expertise.

CO 3.0 Technical and Scientific Viability

NREL continued to enhance its technical capabilities (research staffing, facilities, and equipment) in support of long-term program needs, national energy goals and national environmental sustainability goals through focused investments.

NREL's strategic focus was demonstrated by the completion of the 25-year NREL General Development Vision. Developed with creative NREL leadership supported by a team of nationally recognized architects, including support from Bechtel and collaboration with DOE, this plan provides a framework for developing both the South Table Mountain Site and National Wind Technology Center. Building on the current physical infrastructure, and responding to the many land use challenges presented by NREL's two sites, this effort envisions the development of its very compact campus during the next 25 years to support excellence in state-of-the-art R&D; safe, healthy, efficient, and secure operations; the best principles of sustainable site development; NREL's image of excellence in R&D and sustainability; and positive relations with close neighbors. This vision will guide strategic physical investments at NREL.

MRI and its integrated team of Battelle and Bechtel demonstrate commitment to long-term viability of NREL as a unique national asset that will provide ever-increasing value to the nation.

NREL worked closely with GO in diligent efforts to develop NREL's next major research building, the Science & Technology Facility (S&TF). The S&TF will provide the United States with a unique capability to develop advanced technologies for thin-film and nanostructure fabrication in support of renewable energy and energy efficiency goals.

Recognizing the movement of wind turbine technology toward larger turbines for lower wind speeds, NREL developed plans for critically needed new facilities at the National Wind Technology Center. The current dynamometer and blade testing facilities will continue to support many areas of developing technology, but cannot be expanded to meet the new, larger

requirements. NREL's strategic discussions with industrial stakeholders and DOE led to development of initial documentation for DOE management review.

MRI and its integrated team of Battelle and Bechtel ensure that NREL remains vital by guiding investments that build capabilities for current and future mission needs while protecting and enhancing existing capabilities.

Upgrading and expanding research equipment is another key component in maintaining Laboratory long-term viability. Engendering program support and strategically selected investments, NREL continues to strengthen its long-term capabilities. For example:

- Capabilities in computational science continue to be developed as a fundamental tool for improving productivity and creativity in all areas of research, introducing nearly fifty NREL staff to the opportunities offered by computational science at an internal workshop featuring speakers from DOE.
- A computational chemistry capability was added that will help advance several research areas at NREL.
- Analytical equipment was purchased to begin establishing a new capability to examine the surfaces of biological materials and samples, supporting research in biomass, hydrogen and related areas.
- A clean room and additional analytical equipment were added to expand capabilities in hydrocarbon emissions from fuels.
- X-ray diffraction equipment and a transmission electron microscope were purchased to advance the state-of-the-art of hydrogen fuel cell research, and solar and general solid-state materials research.
- Distributed energy and electric reliability testing equipment was expanded to examine the response of systems to abnormal utility conditions.

The long-term viability of the Laboratory also depends on nurturing new scientific ideas that could lead to significant breakthroughs in support of the DOE mission. As examples, NREL researchers established the capability to analyze X-ray diffraction analyses of single crystals, which will provide new insights for photovoltaic, solid-state lighting, carbon nanotube, and other technologies dependent on solid-state materials. In another area, NREL is developing a new capability to characterize the energy levels of individual nanoparticles, which will yield insights into how best to synthesize and use these new materials in next-generation solar cells, carbon-based hydrogen storage systems, new catalysts, and other materials.

Based on its strategic development of new facilities, infrastructure, and emerging scientific ideas to support the long-term viability of the Laboratory, NREL proposes a rating of ***Outstanding*** for the Technical and Scientific Viability Critical Outcome.

CO 4.0 Mission Support

NREL successfully mitigated negative impacts from late receipt of funding and pension fund pressures that resulted in a stable labor multiplier, timely subcontract awards, and effective GSO management in addition to meeting program AOP commitments. Focus on the factors that support strategic management of human capital resulted in enhanced benefits without increased cost, improved performance management processes, and greater flexibility in how staff accomplish work. NREL stewardship of critical IT, facility and security infrastructure assures the appropriate use and protection of DOE assets and investments. At the same time, NREL continues to be a leader in "walking the talk" in energy efficiency and renewable energy.

MRI and its integrated management team's leadership and commitment to continuous improvement in business and operational systems and processes help NREL meet or exceed business and operating performance expectations.

Through effective design and construction project management, stakeholder outreach, and close collaboration with GO, a critical milestone was met in gaining approval from DOE for S&TF Critical Decision 2, authorizing NREL to complete final design documents for the S&TF before the allocation of construction funds. The DOE Office of Engineering and Construction Management noted that the project both supported the DOE mission and used a design process that ensured that functional requirements were clearly identified and users were heavily involved.

NREL's performance measurement system continues to evolve, providing useful and timely information about where to focus improvements. Process metric trends and staff survey results

support management decision-making and driving productivity gains. For example, the Foreign Travel closeout process, identified as an area needing attention during the first performance period was enhanced with the result of a significant reduction in the number of outstanding closeouts. Other efficiency gains included increased subcontract closeouts and improved efficiency in cost/price analysis and subcontract auditing.

The Lab gained increased external recognition of its improvement efforts as illustrated by the LOB recently identifying NREL's performance-based management approach and its requirement management system as best practices.

Based on its continued record of providing exceptional mission support that enables the S&T mission, NREL proposes a rating of ***Outstanding*** for the Mission Support Critical Outcome.

CO 5.0 Environment, Safety, and Health

NREL's commitment to strong ES&H performance met or exceeded benchmark standards and targets, and incorporated process improvements while providing efficient delivery of support services.

MRI and its integrated team of Battelle and Bechtel ensures that NREL's culture embraces and practices concepts of integrated safety management, and supports strong ES&H results.

Laboratory performance against ES&H benchmark standards continues to be best in class, in comparison to both DOE and private industry. ES&H standards and metrics were further refined to better identify and focus on areas most important to the Laboratory's mission. Coordination with other DOE national laboratories maximized sharing of lessons learned, established more accurate external baselines, and communicated NREL's successes across the DOE complex. Additionally, the Laboratory effectively responded to, and corrected, all factors associated with the potential fire safety issue reported in the previous period, ensuring that all factors were corrected. Lessons learned from this effort resulted in implementation of several best-management practices, which were communicated throughout the DOE complex. Through a cooperative GO/NREL effort, quarterly ES&H briefings are conducted for EERE executive management, allowing them to better understand and communicate how NREL's ES&H performance supports the EERE mission.

The South Table Mountain Site-wide EA was completed under budget, even after the inclusion of two supplemental field studies not included in the original EA scope. Process improvements also resulted in a document that is a more effective planning and management tool than previous EA's, and that is fully coordinated and integrated with other planning documents, such as NREL's 25-year General Development Vision. EA's also were completed in support of several significant off-site projects. These activities support the EERE mission by making full use of increased environmental expertise developed within the Laboratory over the past year.

The Laboratory took significant steps toward gaining formal recognition of its environmental management system. The Laboratory's leadership in areas such as management of workplace injuries, sustainability and environmental management resulted in NREL and DOE-GO staff jointly presenting these success stories through various external forums. Again in coordination with DOE-GO, the Laboratory has pursued integration of its ES&H systems with those of a major EERE program.

A rating of ***Outstanding*** for Critical Outcome 5.0, Environmental, Safety and Health is proposed, based on performance results, process improvements, and support of the EERE mission both within and external to the Laboratory.

6.0 Outreach and Stakeholder Relations

NREL's performance in outreach and stakeholder relations was exceptional. The Lab's media outreach strategy delivered striking results in terms of national visibility for DOE and NREL, especially as evidenced by the unprecedented media coverage of DOE's American Solar Challenge. Two key goals – increasing awareness of the DOE and NREL missions, and gaining significant visibility for DOE and the Laboratory along Colorado's Front Range – met with

extraordinary results. Initiatives to build working relationships with key media and public policy stakeholders continued to show significant results, with several national leaders praising the Laboratory's research and staff in public appearances. National visibility for DOE and NREL also grew dramatically as the Laboratory built new, and nurtured existing, relationships with leading journalists and capitalized on national "issues in the news" to gain recognition for energy efficiency and renewable energy technologies. The growing success of NREL's Colorado Executive Outreach (CEO) program brought new business and government leaders to the Laboratory to build networks and key alliances. This performance period was marked by major successes in introducing DOE and NREL to new local stakeholders and in seeing an unparalleled number of visitors to the Laboratory. A community leaders breakfast at the National Wind Technology Center, and an aggressive strategy to offer special events and better programming at the Visitors Center – such as the 2-day Consumer Energy Expo – attracted a record number of visitors to NREL.

MRI and its integrated management team support NREL's outreach communication and education strategies that deliver exceptional results.

NREL's leading-edge communications technologies were pivotal in providing technical expertise and efficient high-quality communications products for the Laboratory's researchers and their programs. For example, NREL's extensive knowledge of solar and hydrogen technologies and industries helped these programs more clearly present and articulate their ideas, increasing the effectiveness of these plans.

NREL's education programs benefited from programmatic growth, strategic partnerships and enhanced outreach, positioning NREL and DOE to take advantage of even greater opportunities in FY04. Increased EERE and NREL national visibility in the science education community is a positive outcome of leveraging significant external investments in the Laboratory's education programs. A substantial BP America partnership with NREL has produced a Renewable Energy and Efficiency Education outreach vehicle providing a showcase of DOE/NREL research and technology for new, broader audiences. In recognition of the Laboratory's excellence in education program management, partners joined forces with NREL to deliver education outreach to greater numbers of students and educators than ever before. New fuel cell and hydrogen education workshops highlighted a continually evolving NREL/Colorado School of Mines collaboration reaching over 200 local and national middle school students and teachers. As a result of the exceptional program execution of the 2003 DOE National Middle School Science Bowl, DOE's Office of Science awarded NREL leadership of the 2004 National Middle School Science Bowl. This new responsibility will allow DOE and NREL to reach greater and more diverse audiences, and providing yet another opportunity to take the renewable energy and energy efficiency message across the nation.

A rating of ***Outstanding*** for Critical Outcome 6.0, Outreach and Stakeholder Relations is proposed, based on the exceptional results of NREL's outreach and communications.

CO 1.0 Science and Technology – MRI will deliver high-quality scientific and technological outcomes that advance DOE priorities and Program objectives.

NREL Proposed Grade: Outstanding

PO 1.1 Demonstrate the quality of scientific and technological outcomes.

PI 1.1.1 Results of external and peer review validate the quality and impact of programmatic technical and/or analytical outcomes

PI 1.1.2 External recognition focused on NREL's technical and/or analytical work and outcomes: a) external awards and recognition; b) peer reviewed publications, and c) number of patents awarded.

Assessment Summary

NREL continues to produce high-quality science and technology. This is especially demonstrated by peer reviews and NREL's response to those reviews. During the last six months of FY03, NREL participated in six peer reviews involving the Photovoltaics subprogram; the Biomass program; the Hydrogen, Fuel Cells, and Infrastructure program; the FreedomCAR and Vehicles Technologies program; and the Wind and Hydropower Technologies program. It is also demonstrated by the external recognition that NREL has received. The Laboratory has, for example, won another R&D 100 Award for technological innovation. This is the fifteenth year in a row that NREL has won at least one of these prestigious awards, bringing the Lab's total to 35 since 1982; a remarkable number given NREL's size and the number of scientists and engineers it has in relation to other DOE National Laboratories.

	R&D 100	Peer Reviewed Publications	Patents Awarded
NREL Average per 100 Technical Staff* FY03	.30	66.77	5.4
NREL Average per 100 Technical Staff* FY02	.93	59.20	3.1
DOE Lab-System ** Average per 100 Technical Staff*FY93-FY02 Combined	.16	56.09	1.86
NREL Average per 100 Technical Staff* FY93-FY02 Combined	.71	67.41	5.24
*Technical Staff = Number of scientists and engineers **Labs used for benchmark:Ames, ANL, BNL, LANL, LBNL, LLNL, ORNL, PNNL, SNL			

NREL continues to demonstrate outstanding performance in these areas when compared to the benchmark of eight other laboratories.

Indicative of its vitality as an R&D institution, NREL was very active in publications, inventions, and patent activities. Out of the 1,116 publications produced by NREL staff, more than 900 were technical publications; and of these, 233 were peer-reviewed journal articles. The technical staff also submitted 60 records of invention, 22 U.S. patent applications, 26 foreign patent applications, and 12 PCT (patent cooperative treaty) applications; and was issued 14 U.S. patents and four foreign patents.

Highlights

Peer and Other Technical Reviews

Peer review, often cited as the most effective form of research assessment, provides an important evaluation of the relevance and quality of NREL research. NREL uses results of these reviews in planning future R&D and building technical capabilities.

- ***National Advisory Council Reviews Basic Energy Sciences.*** The Council reviewed NREL Basic Energy Sciences research. The Council noted the science is sound and world-class, and has the potential to contribute to energy challenges and opportunities. A distinguishing feature identified was that the basic theoretical and experimental research is well linked to the applied science and engineering at NREL.
- ***Wind & Hydropower Technologies Program Peer Review.*** A joint peer review meeting was held for the Wind and Hydropower Technologies Program. The meeting focused on strategic programmatic directions presented in the multi-year program plans, and on a high-level strategic review of ongoing RD&D activities. In addition to an independent peer-review panel, two industry associations American Wind Energy Association (AWEA) and National Hydropower Association (NHA) participated in the reviews and provided valuable feedback. The review

panels commended DOE and NREL for the excellent job they were doing managing the programs within the constraints of existing funding. Both the AWEA R&D committee and the peer review panel recommended that the Wind Program increase its emphasis on utility integration and wind resource measurements at the level of the new larger wind turbines (100+ meters). They also expressed their concern that the "cost of energy" was being used as a sole metric for measuring progress and performance. In response to this feedback, the Wind Program is enhancing its FY04 activities in the areas identified and is augmenting its "cost of energy" metric with other metrics within the Multi-year Program Plan.

- ***National Bioenergy Center (NBC) Peer Reviews.*** NBC hosted and conducted three peer reviews since April 2003. The areas of review were: Advanced Biomass Pretreatment Research, Enzyme Sugar Platform Research, and Syngas Platform Research. The Pretreatment and Enzyme Sugar Platform Research were conducted as interim stage reviews with more than 50 attendees representing DOE, USDA, industry, and academia, including many companies partnering with DOE and the national laboratories in CRADAs. The Syngas Platform Research Review encompassed seven projects, including all of PNNL's research, as part of the NBC, as well as most of NREL's Syngas R&D. Feedback from all three reviews was supportive of the research being done in the NBC. The first two reviews required very little adjustment to the Lab's research. The results and peer input from the review of the Syngas Platform Research are still being collected; but the review is expected to have significant impact on the direction of NREL's research.
- ***DOE PV Peer Review.*** The DOE PV Subprogram conducted a peer review of the Thin-Film PV Partnership and the PV Module and System Reliability activities. A DOE-selected panel reviewed 19 in-house and subcontracted projects, of both NREL and SNL. The initial feedback from the panel was positive; a full report is expected in early FY04, and will be used to guide FY04 research activities and priorities.
- ***Crystalline Silicon PV Subcontracts Peer Review.*** NREL conducted an in-depth peer review of seven university subcontracts supporting exploratory R&D in crystalline silicon areas identified by the U.S. PV industry. Based on 20-minute presentations and question-and-answer sessions, reviewers from BP Solar, SunPower, Evergreen Solar, Texas Instruments, RWE-Schott Solar, and a private sector crystalline silicon consultant identified strengths and weaknesses of the R&D. Suggestions resulting from this peer review will be used to redirect the next phase of research activities by the universities.
- ***Hydrogen, Fuel Cells and Infrastructure Technologies Program Peer Review***. DOE held its program review in May. Several NREL projects were reviewed on hydrogen production, storage, and fuel cells. All NREL projects were highly rated. As a result, the Lab will use the reviewers' comments to direct planning for the future of each project.
- ***USABC & FreedomCAR Technical Review.*** In May, July, and September, members of the U.S. Advanced Battery Consortium (USABC) and the FreedomCAR energy storage technical team reviewed NREL's technical progress on battery thermal analysis; a proposed thermal test procedure, a new calorimeter design; fuel-cell vehicle energy storage simulations; and battery modeling. The review team provided positive feedback on the relevance and quality of NREL's work. NREL is using the feedback to refine the thermal test procedure/calorimeter design and further define R&D projects for FY04.

External Recognition of NREL Technical Leadership

External recognition validates the quality, uniqueness, value, reputations, and contributions of Laboratory staff and NREL-produced science and technology. Examples of external recognition that the Laboratory received this period include:

- ***R&D 100 Award.*** NREL and First Solar, Inc. shared a 2003 R&D 100 Award for the development of "High-Rate Vapor Transport Deposition for CdTe PV Modules." This high-speed deposition technique enables in-line, continuous manufacture of efficient, low-cost, thin-film photovoltaic modules. It is the worlds first such mass-production method for making polycrystalline thin-film modules more than 10 times its nearest rival. This award brings NREL's total R&D 100 Awards to 35.

Vacuum chambers that house award winning high-rate vapor transport deposition system (HRVTD). The HRVTD can coat a 60 cm x 120 cm substrate with layers of CdTe and CdS semi-conductor material in 40 seconds.

- ***MacFarland Award.*** The Society for Automotive Engineers presented Wendy Clark with the

MacFarland Award, which is given to individuals in recognition of their contributions to industry over a sustained period.

- ***National Academy of Engineering Recognition.*** The National Academy of Engineering recognized Steve Slayzak as a leading young engineer for his work on liquid desiccant air-cleaning systems, and systems that can protect buildings from weaponized biological and chemical aerosol attacks.
- ***DOE Outstanding Mentor Award***. The DOE Office of Undergraduate Research Programs recognized Bonnie Hames and Kim Magrini-Bair for their dedication as mentors, sharing knowledge and inspiring and instilling confidence in the next generation of scientists and engineers.
- Cover Story Recognizes Value of Research. The Journal of Physical Chemistry recognized the value of research by Brian Gregg by highlighting his research on the cover of its May issue, and including his article "Excitonic Solar Cells, a New Mechanism Converting Sunlight into Electricity."
- In this research, the scientist proposed a new mechanism by which light is converted to electricity in organic semiconductors.
- ***Outstanding Young Scientist.*** Juki Yoshida, working on her Ph.D. research was recognized by the Third World Conference on Photovoltaic Energy Conversion as an "outstanding young scientist" for work performed on transparent conducting oxides for polycrystalline photovoltaics.
- ***EPA Award to NREL/DOE Building America Program.*** NREL received a 2003 ENERGY STAR for Homes Outstanding Achievement Award from EPA for providing technical leadership for the DOE Building America Program that resulted in the construction of more than 4000 ENERGY STAR homes last year.
- ***Best Paper Awards.*** Several NREL researchers received awards for best paper, including:
  - Two papers presented in different research categories at the Third World Conference in Photovoltaic Energy Conversion, held in Osaka, Japan.
  - A paper co-written by Ahmad Pesaran received the Vincent Bendix Automotive Electronics Engineering Award from the Society of Automotive Engineers (SAE). The award is given annually to recognize the best paper presented at all SAE meetings on the subject of automotive electronic engineering.

Elections and Appointments

David Renné was appointed associate editor for resource assessment of the Solar Energy Journal. This appointment recognizes the leadership NREL has attained through its support of the solar resource characterization project, which the scientist leads.

Helena Chum was appointed as a member to the Technical Advisory Committee to the California Integrated Waste Management Board, which assesses alternative pathways for biomass residues to energy, fuels, and other potential products.

Invited Leadership, Lectures, and Publications

Recognition of Laboratory staff by scientific and professional communities is indicative of the quality and importance of the work conducted by NREL to advance science and technology. Of particular importance are invitations to convey knowledge about renewables and energy efficiency to energy stakeholders outside the renewables community and to international audiences. NREL staff members received numerous invitations to write articles and to give talks that addressed a wide array of audiences and of renewable energy subjects. Among these were:

- A keynote address was given at the 2003 Glass Processing Days conference in Finland. The address, entitled "Stay Cool with Advanced Automotive Glazing," focused on air-conditioning fuel use and potential savings with advanced climate control techniques such as solar reflective glazings. As a result of the presentation, numerous companies inquired about working with NREL.
- Arthur Nozik presented "Carrier Dynamics in Semiconductor Quantum Dots and Potential Applications to High Efficiency Solar Photon Conversion," at the 203rd Meeting of the Electrochemical Society in Paris, France.
- Ahmad Pesaran presented his invited paper, "Energy Storage Systems Requirements for Fuel Cell Hybrid Vehicles" at the Advanced Automotive Battery Conference in Nice, France. This is a premier meeting on automotive batteries and it provides a forum for communication and coordination of work being conducted for DOE.
- David Ginley presented a plenary lecture at the 1st International Solar, Wind, and Hydrogen Meeting held in Spain.
- Several invited talks and plenary lectures were presented by NCPV staff members at the 3rd World Conference on Photovoltaic Energy Conversion in Osaka, Japan. This included a plenary presentation by

Tom Surek, "Progress in U.S. Photovoltaics: Looking Back 30 Years and Looking Ahead 20."

Conference Chairs and Organizers

Like invited lectures, being invited to organize and/or chair a major conference recognizes the national and international reputation of NREL researchers and organizations. During this period:

- The Materials Research Society (MRS) requested Rommel Noufi chair its 2003 fall meeting. This is a major recognition, as the prestigious event attracts several thousand attendees from all over the world. While NREL scientists have been quite active in the MRS for many years and have served as organizers for many of the symposia, this is the first time an NREL scientist was chosen to lead the conference. David Ginley was asked to chair the MRS conference for the fall meeting of 2005. Rarely has the Society turned to one organization for two leaders in such close succession.
- Tim Coutts and John Benner were invited to serve as chairs for the 31st IEEE Photovoltaic Specialist Conference, to be held in January 2005. John Benner and Lawrence Kazmerski were chosen to be on the International Advisory Committee for the 19th European Photovoltaic Science and Engineering Conference.
- David Ginley served as co-organizer of the conference on Transparent Conducting Oxide Thin-films for Electronics and Optics in Tokyo, Japan. Howard Branz was invited to co-organize the 22nd International Conference on Amorphous and Microcrystalline Semiconductors to be held in 2007.
- Michael Himmel chaired the Gordon Research Conference on Cellulases and Cellulosomes held in Hanover, New Hampshire. Gordon Research Conferences provide an international forum for the presentation and discussion of frontier research in the biological, chemical, and physical sciences, and their related technologies.
- Wendy Clark served as co-chair of the 2003 meeting of the Japan Society of Automotive Engineers/Society of Automotive Engineers International Fuels and Lubricants, held in Yokohama, Japan. Clark also presented the welcoming speech for this meeting. The meeting provides a forum for fuels and lubricants researchers from the United States, Asia, and Europe to discuss R&D issues.

Refereed Journal Articles and Intellectual Property

Two of the most important and historically recognized metrics for scientific achievement and technological progress are, respectively, refereed journal articles and patents. During FY03:

- NREL researchers wrote and published 233 peer-reviewed articles in a wide spectrum of highly respected journals.
- The Laboratory had an active year for intellectual property, culminating in 18 patents.

PO 1.2 Demonstrate excellence in program planning and management.

PI 1.2.1	Project management performance as measured against key milestones, budgets, subcontracting goals, and other commitments as negotiated and represented in approved AOPs.
PI 1.2.2	Program planning activities result in sound technical plans and well-developed longer-term program directions.
PI 1.2.3	Effective partnering and communication occurs between NREL and DOE program managers.

Assessment Summary

NREL executed its program roles through effective and agile program management that enabled meeting commitments and key milestones. The enhanced communications and closer working relationships between NREL and EERE programs noted in the first self assessment were continued and enhanced in the latter part of the year. This was most evident in NREL's significant involvement in providing technical leadership, strategic advice, and credible analyses to support the development of DOE multi-year technical plans and integrated annual operating plans. As a result, high-quality technical plans are emerging in each program and NREL efforts are aligned with the objectives of these plans. In several programs, such as the Biomass Program, NREL integrated efforts among laboratories, with industry, and among programs and addressed the recommendations from external reviews to ensure that individual efforts are aligned and mutually supportive of overall program goals. The enhanced role of NREL as a technical advisor and strategic partner in planning has yielded high-quality technical plans, such as the

multi-year RD&D plan for the Hydrogen, Fuel Cell, and Infrastructure Technologies Program, which was well-received by the National Research Council. NREL's analytical capabilities provided value to DOE planning by validating program technical targets, such as the preliminary system and component level targets for the heavy hybrid vehicles under the FreedomCAR and Vehicle Technologies Program and by bringing a systems perspective to program planning, such as in the Solar Technologies Program.

In executing its program responsibilities, NREL awarded $97M in subcontracts, 83% of these awarded on a competitive basis, thereby exceeding its annual goal of 70%. NREL's technical oversight of these subcontracts and the technical integration of subcontracted efforts with internal R&D continue to yield accomplishments that are advancing DOE's goals. NREL partnered effectively with the Golden Field Office to provide technical support to projects that are executed through the GO Project Management Office. NREL participated in the rollout presentation of the interim EERE corporate management system and began to plan how best to support its implementation in FY04.

The following examples highlight NREL's high standards and ongoing excellence in program planning and management.

Program Planning and Management Highlights

NREL supported DOE by serving as the technical integrator to develop multi-year RD&D plans and/or annual operating plans (AOPs) for the Biomass; Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT); Solar; and Wind Programs. In several cases, the technical support was facilitated by strategic assignment of staff to the NREL Washington, D.C. office.

- ***Draft HFCIT RD&D Plan Serves as Model.*** For the HFCIT Program, NREL provided technical support to establish the R&D agenda for the period FY04 - FY10 by recommending technical targets and milestones, designing technical approaches to overcome barriers, and designing and producing a draft multi-year RD&D plan for DOE. NREL also designed a change control process to manage the process of addressing comments on the plan.
- ***NREL Supports Development of First Integrated Solar Multi-Year Technical Plan.*** Working closely with Sandia, NREL played a significant role in the timely publication of the first-ever Multi-Year Technical Plan for the Solar Energy Technology Program. The plan projects goals to 2025, but focuses on the first five years of the technical programs and uses the system-driven approach to program management. Developing this plan was supported through assignment of technical staff in Washington, D.C.
- ***NREL Integrates Comprehensive Biomass MYTP Across Multiple Participants.*** NREL led the development of the MYTP and coordinated participation by GO, NETL, and all the labs in the NBC (NREL, ORNL, PNNL, INEEL and ANL). The plan includes work in feedstocks, the sugar platform, the thermochemical platform, products, and integrated biorefineries. It integrates decisions and plans developed as part of the ongoing stage gate management process and links technical work to the program's goals and strategies as spelled out in the MYPP.
- ***D.C. Support Enables Developing Wind & Hydropower Technologies Technical Plan.*** NREL provided technical support to the DOE Wind & Hydropower Technologies Program tailored to support DOE needs in multi-year program planning; annual program planning and execution; R&D portfolio evaluation and performance metrics; and the renewable energy title of the farm bill. Support was provided on technical analyses in critical areas such as offshore wind feasibility and wind produced hydrogen by electrolysis.
- ***NREL Leadership Supports Developing Key Subprograms Plans.*** In the FreedomCAR, Geothermal, Federal Energy Management Program, Weatherization and Intergovernmental, and Distributed Energy and Electricity Reliability Programs, NREL led the integration of key technical thrusts and/or participated actively in developing technical input to roadmaps and multi-year and annual plans. As examples:
  - NREL led efforts with DOE to organize and develop the Advanced Heavy Hybrid Propulsion Systems (AHHPS) R&D plan inputs to the Vehicle Systems R&D Plan. The R&D plan was integrated and coordinated with the 21st Century Truck Partnership (CTP) Heavy Hybrid "White Paper", including technical targets, barriers, and tasks, in an effort to keep Vehicle Systems research and development relevant to 21st CTP goals and objectives.
  - NREL worked closely with OWIP to prepare a five-year plan for the EERE International Program that

establishes strategic objectives and guiding principles, identifies core EERE international services, defines seven priority countries, and proposes six global and regional initiatives to be implemented FY04 through FY07.

- ***Web-Based Tools Facilitate Planning and Program Management.*** Several programs implemented new tools to facilitate planning and program management. For example, initial planning for the FY04 Solar Technologies Annual Operating Plan (AOP) was completed using a Web-based database system. This approach resulted in the earliest ever AOP draft for the program and enables DOE funding authorizations in early FY04. A limited-access intranet site was created for the NBC Laboratory Coordination Council to improve and maintain communications with DOE and all NBC labs.
- ***Major Solicitations Attract Quality Proposals.*** NREL conducted several major competitive solicitations during this period. As examples, two competitive PV solicitations, based on ongoing peer reviews to establish R&D priorities, together attracted 73 responses. The competition for "University R&D for Future Generation Solar Electric Technologies" attracted proposals from many of the top universities. Under the High Performance PV project solicitation, "14 proposals were selected for negotiations for award. The PV Manufacturing R&D project solicitation drew a higher response from the U.S. PV industry than was anticipated, representing a 30% increase in responses over the FY00 solicitation. In response to the solicitation for the "Minority University Research Associates Program," eight proposals were received from minority-serving institutions
- ***Technical Support Provided to DOE Solicitations.*** NREL provided technical support to several Golden Field Office (GO) solicitations. For example, NREL technical experts conducted reviews of nearly 70 Tribal Energy proposals supporting DOE selection of 16 awards to tribes totaling $2.9M. NREL continued to provide technical support to GO on two Wind Program research activities: the Field Verification Project for Small Wind Turbines (FVP) and Low Wind Speed Technology for Small Turbine Development Project (Small Turbine Project). In support of the Small Turbine Project, NREL provided technical assistance to GO on the pre-award process. The Small Turbine Project is an integral part of the Wind Program's Distributed Wind Turbine effort to help industry develop advanced technology that will allow distributed wind turbines to compete in lower wind speed sites in the United States for a wide variety of applications.
- ***Aggressive Steps Taken to Reduce Uncosted Balances.*** For example, NREL project managers worked diligently to reduce the carryover in the Photovoltaics subprogram from more than $17M at the end of FY02 to less than $8M (projected) at the end of FY03. In its FEMP efforts, NREL executed an aggressive plan to reduce uncosted balances from the FY02 level of $1.9M to an FY03 level of $1.1M. The continuing resolutions through the early part of FY03 made these accomplishments, and overall GSO management, even more significant.

Analytics Strengthen Program Planning

NREL was instrumental in strengthening the analytical foundation for program planning. In addition, NREL continued to work to integrate analytic efforts across programs. Example highlights include:

- ***Enhanced Vehicle System Technical Targets Tool Helps Establish Targets.*** The technical targets tool used to analyze DOE's FreedomCAR and Hydrogen, Fuel Cell, and Infrastructure program goals was enhanced to include a fully functioning graphical user interface, a design-of-experiments module for performing sensitivity analysis, and links to the distributed computing and optimization software NREL was using and improving. NREL completed a critical milestone to show preliminary system and component-level technical targets for heavy hybrid vehicles. The newly developed technical targets, where none had existed before, will help DOE and NREL establish critical R&D priorities and help direct the Advanced Heavy Hybrid Propulsion System (AHHPS) subcontracts toward critical technologies and heavy vehicle design approaches that satisfy program objectives of doubling heavy vehicle fuel economy.
- ***New Solar Model Enables Systems-Driven Approach.*** NREL and SNL worked together to develop a new Solar Analysis Modeling Program to enable a system-driven approach to program management.
- ***Comprehensive Study of Biomass Syngas Processes and Products Completed.*** NREL completed an important first step in identifying the most promising, cost effective fuel synthesis technologies where biomass thermochemical conversion could have a significant impact. Seven different syngas utilization processes and 14 products were evaluated. Fuel products included hydrogen, Fischer-Tropsch liquids, methanol, ethanol, dimethyl ether, and mixed alcohols. The report summarizes salient points regarding the processes and products considered including technology status and description,

chemistry, catalysts, reactors, syngas cleanliness requirements, process and environmental performance, and economics. The results of the analysis will help direct R&D efforts on selected products and processes with high likelihood of economic return and environmental benefits.

- ***Final Solar Diligence Report Completed.*** Under subcontract to NREL, Sargent & Lundy issued a final report on their due-diligence review of solar power tower and parabolic trough technologies. The conclusions provide a sound technical basis for R&D activities to lower the cost of CSP technologies and for providing continued analytical support for investigating the feasibility of deploying 1,000MW of CSP systems in the Southwest.
- ***Meetings Convened to Coordinate Analysis Across Programs.*** In addition to providing analytical support within individual programs, NREL convened several meetings to coordinate analysis efforts among programs and between TD and PBFA. For example, the first coordination meeting for hydrogen analysis was held with 17 organizations participating. NREL also hosted a Biomass Analysis Roundtable meeting in preparation of an OBP Multi-year Analysis Plan (MYAP). Attendees included analysts from OBP-HQ, all NBC labs, GO, and USDA.

Effective Partnering and Communicating

Increasingly, opportunities for advancing DOE's strategic goals are found at the interfaces among programs. NREL assisted EERE in defining these program interfaces. This resulted in a significant increase in interactions and collaborations between programs that yielded new opportunities or cooperative execution of related activities. In every program, NREL worked across the lab systems, with industries, and/or universities to enhance relationships that are key to planning and accomplishing program objectives. For example:

- ***Interfaces Between Hydrogen and Other Programs Defined.*** NREL assisted DOE in defining the hydrogen-biomass scope by proposing the identification of "mutual technologies of interest" to the two DOE programs. NREL provided a draft chart of collaborative hydrogen activities across DOE spanning hydrogen production through use in both stationary and transportation applications. NREL led a joint effort between the Hydrogen, Fuel Cells, and Infrastructure Technologies and Wind Programs to study the opportunities for producing hydrogen from wind.
- ***Distributed Energy Interfaces Managed.*** NREL maintained a well-integrated interface among the RD&D efforts that will remain in EERE and those that have transferred to the new DOE Office of Electric Transmission and Distribution (OETD). This ongoing focus on interfaces is important to leverage knowledge and capabilities effectively.
- ***Multi-Partner Collaboration Yields Strategy for Carbon Storage Research and Proposal for Virtual Center.*** NREL convened and chaired the Carbon Materials Working Group that identified potential RD&D strategies and laid the foundation for a proposed DOE virtual center on hydrogen storage on carbon-containing materials..
- ***National Collaborations Support Identifying Solar Technology Research Directions.*** NREL continued a highly successful series of national meetings in various solar technology areas, including CdTe, amorphous silicon, thin-film module reliability, and crystalline silicon, which are key to identifying future research directions and priorities.
- ***NREL Leadership Unites Nevada Organizations Around a Shared Plan.*** NREL worked closely with the Nevada Southwest Energy Project (NSWEP) board, comprised of representatives from the Nevada State Office of Energy (NSOE), Desert Research Institute, University of Nevada Las Vegas and University of Nevada Reno, to develop a unified voice to create and implement a plan for establishing Nevada as a recognized Southwest center of excellence in renewable energy research (including transmission and distribution infrastructure issues associated with renewable energy technologies).

PO 1.3 Produce S&T accomplishments that advance DOE and program objectives.

PI 1.3.1 Programs and projects produce significant research and development accomplishments that positively impact the advancement of DOE missions and program goals.

Assessment Summary

During the latter half of the year, NREL's science, technology, and analytical efforts yielded accomplishments that are moving DOE programs toward meeting their technical targets. These accomplishments include scientific and technological advances that result in reducing the cost or increasing the reliability of DOE-supported

technologies or that remove key barriers to their use. Key S&T accomplishments were made in every program, examples of which include demonstrating bench-scale production of hydrogen from waste plastic; significantly exceeding the target cost reduction for cellulose enzymes; completing long-term tests that show that diesel particle filters remain effective over time; receiving final approval of the distributed generation interconnection standards; validating the efficacy of liquid desiccant technology to deactivate anthrax spores using MRI's certified biosafety laboratories; increasing solar cell efficiencies; conducting independent tests of innovative NREL air-cooled condensers that show heat transfer coefficients are higher by as much as 80% than conventional designs; and advancing the understanding of nocturnal low-level jet streams in order to understand the potential impact on low wind speed turbine designs. Highlights of key accomplishments are summarized for each of the technology development programs below.

Biomass

- ***Genencor Exceeds Cost Reduction Target for Cellulase Technology.*** Genencor International (GCI) successfully completed its 3-year subcontract with NREL, exceeding the target of a 10-fold cellulase cost reduction by achieving an overall 11.1-fold cost reduction. The technical progress achieved by GCI will considerably enhance the likelihood that cellulase enzymes will be cost effective and available for the nascent bioindustry. Improvements made to the cellulase production process and to enzymes led to the significant overall improvement. During the subcontract, NREL worked closely with GCI evaluating new enzymes by testing them on real substrates, auditing production process improvements, and calculating cost reduction factors compared to the technology baseline using the bioethanol process model.
- ***Small Modular Biopower Systems Installed.*** Community Power Corporation (CPC) fabricated and completed field installation of three15-kW demonstration systems to SBS Wood Shavings in Ruidoso, New Mexico, American Forest Products in Zuni Pueblo, New Mexico, and Walden High School in Walden, Colorado. These field demonstrations constitute the final phase of a multi-year collaborative project by DOE, the U.S. Forest Service, and CPC. Goals for the field demonstrations include evaluating performance and correcting design flaws identified during long-term operation or in extreme operating environments. Following this demonstration phase the technology is expected to be ready for commercialization. The U.S Forest Service is interested in the technology as a productive use of forest thinnings resulting from forest fire mitigation activities.
- ***Successful Integrated Gasifer-Microturbine Operations.*** Extended microturbine operation on medium energy density fuel gases produced by gasifying biomass in the Thermochemical Process Development Unit (TCPDU) established the performance and exhaust emissions of the Capstone microturbine on hydrogen-rich fuels. As part of the effort to demonstrate the suitability of cleaned syngas for biorefinery utilities operations, the work was performed with the technical assistance of Capstone through a CRADA.
- ***High Sugar Yields Achieved at High Solids Loadings in Pilot Scale Pretreatment Reactor.*** Technoeconomic analysis indicates that solids loading in the pretreatment reactor have a major impact on the cost of producing sugars from biomass. For example, increasing solids loading from 20% to 30% results in reducing the cost of ethanol production by up to \$0.26¢/gallon. The technical target of greater than 30% solids loading in the Sunds pretreatment reactor was exceeded with 35% solids loading achieved. Sugar targets of 90% cellulose digestibility and 85% hemicellulose yield were met and exceeded respectively with conversion of 90% of the cellulose and xylan in the corn stover to monomeric and oligomeric sugars by the combined dilute acid and enzymatic cellulose hydrolysis processes at solids loadings near 30%. This extremely promising result suggests we are closer to achieving the technical targets required for a cost-effective process.
- ***Diffusion of Glucose at the Aqueous Boundary Layer of a Cellulose Microcrystallite Using Computational Chemistry.*** Computational simulations of "hydrolyzed glucose" at the cellulose microcrystallite boundary layer in water and the effects on the diffusion rate of glucose to the bulk medium have helped us understand why up to 65% of the potential released glucose is "lost" in some thermochemical hydrolysis reaction configurations. Bench scale experiments using polar solvents such as ethanol where completed which have shown that the presence of very dilute solutions of ethanol result in less unaccountable losses of glucose. Molecular modeling simulations, in conjunction with ongoing experimental efforts, suggest that glucose release from the cellulose surface involves significant perturbation energy which can be mitigated by the addition of polar solvents in a continuously flowing reactor system. The goal of the combination of

molecular modeling and bench scale experiments is to understand biomass carbohydrate hydrolysis mechanisms in aqueous systems, enabling improved biomass fractionation processes.

- ***Novozymes Demonstrates Lower Cost Cellulase Technology.*** Novozymes Biotech Incorporated made excellent progress and achieved the subcontract intermediate milestone goal of reducing the cost of commercial cellulases five-fold through reduction in processing and production costs. The milestone was met by two significant results: genetic modification of the cellulase production strain to express an important new component enzyme and addition of a new cellulase mixture that improves performance of the cellulase at elevated temperature by a further two-fold. The improvements resulted in reducing the required protein loading, yielding an overall 4.52-fold cost reduction. Combined with earlier process improvements, the five-fold cost reduction was achieved.
- ***Determined Structural Origin of Thermal Tolerance of Enzyme from Directed Evolution and Site Directed Mutagenesis.*** A map of the "hot spots" of T. fusca beta-glucosidase, where mutations led or can be expected to lead to increased thermal stability, was determined. A structural examination of the enzyme was based on computer modeling performed at NREL in collaboration with scientists at the University of Arkansas. Predictions of changes leading to thermal stability were generated and tested by site-directed mutagenesis. Success in these targets has laid the groundwork for FY04 efforts to determine whether this knowledge can be extended to engineering thermal tolerance into other enzymes in the same "family"; other family-1 glycosyl hydolases (GH). We expect this work to benefit industry in the near term by shortening the time required to develop new thermal tolerant family-1 (and perhaps other GH family) enzymes by protein engineering.

Building Technologies

- ***Building America Implementation of Technical Goals.*** NREL continued to work with the Building America (BA) teams to implement the new whole building integration R&D that can achieve 40-70% energy savings goals in new residences. The NREL-developed Building Optimization (BE-Opt) analysis tool is being used to evaluate least-cost system solutions at the 40%, 50% and 70% energy savings levels relative to the BA benchmark house as a function of housing type and climate zone.
- ***NREL Leads Development of Benchmark Research.*** Working in collaboration with Residential Energy Services Network (RESNET) and Pacific Northwest National Laboratory (PNNL), NREL has developed a research benchmark that will be used to evaluate progress toward residential building R&D goals. The benchmark includes a detailed description of all residential building loads including heating, cooling, lighting, hot water, appliances, and other plug loads.
- ***Habitat House Receives Highest E-Star Rating.*** NREL continued detailed energy performance monitoring of several Building America test houses as well as the Habitat for Humanity house sponsored by MRI and its integrated team of Battelle and Bechtel, and built by NREL and GO volunteers. As a result of several advanced energy efficiency features, solar hot water radiant heating, and a 1.5kW PV system, the Habitat house uses 79% less natural gas and 76% less electricity than a typical Colorado house of the same size. It received an E-Star rating of 95, the highest of any rated house in Colorado.


Habitat House

- ***Zero Energy Homes (ZEH) Optimization Analysis.*** NREL has used the BE-Opt analysis tool to determine the least-cost strategy to achieve Zero Energy homes in different climate zones. "An Optimization Methodology for Zero Net Energy Buildings" received the Best Paper Award for Solar Buildings and Conservation at the 2003 ASME International Solar Energy Conference in March.
- ***ZEH System Integration Procurement.*** Seven proposals were recommended for awards in response to the "Zero Energy Homes Energy Supply Systems Integration" solicitation that NREL issued and evaluated on a fast track schedule this period. The objective of this R&D solicitation was to initiate development of residential building-integrated products that incorporate the onsite generation of solar electric and solar thermal energy. Four of the contracts were awarded in FY03 with the remaining three awards subject to the availability of FY04 funding.
- ***Contractor Teams Complete Zero Energy Homes (ZEH).*** The ZEH contractor teams had two major accomplishments this period. The NAHB Research Center partnered with builder John Wesley Miller to complete a ZEH in the Armory Park del Sol development in Tucson, Arizona. The grand opening of the Clarum Homes 256 Zero Energy Home development in Watsonville, California took place in August.

- ***High Performance Buildings Case Studies Completed.*** NREL completed draft reports on design and detailed energy performance analysis of six major high-performance buildings. All of the buildings were 40% to 70% more energy efficient than code requirements and several had PV integrated electric generation and solar hot water. For five of these buildings, the Laboratory participated in the entire process, from building concept through design, construction, commissioning, and two years of performance data. NREL documented recommissioning and monitoring needed for the sixth building to help meet the original energy goals.
- ***NREL Leads New IEA Buildings Task.*** The IEA Solar Heating and Cooling committee selected Ron Judkoff as operating agent for the new Task 34/43 on building analysis software validation. These IEA tasks involve validation methods developed and field-tested by NREL and leading building R&D organizations around the world. They underpin ANSI/ASHRAE Standard 140, which addresses standard methods for testing and evaluating building energy analysis models.
- ***Innovative Electrochromic Window Coatings Evaluated.*** NREL has completed the first 10,000 cycles of testing for 35 prototype electrochromic devices supplied by Enki Technologies. The devices employ unique LANL-developed coating materials and were subjected to our small sample-screening test, which is designed to evaluate the degradation effects of various environments of light, cycling, and temperature.
- ***Energy-10 Software Development Effort Refocused.*** The ENERGY-10 development team concluded that it could not deliver Version 2.0 as originally intended within the current funding constraints due to unforeseen difficulty in modifying the ENERGY-10 legacy code so that it can implement multi-zone models and interact with newer software modules. Therefore, this task was refocused to deliver an update to the current two-zone version and to complete the SKETCH-10 user interface that allows rapid and intuitive description of building geometry and can provide an export file to EnergyPlus.

Distributed Energy and Electricity Reliability

- ***IEEE Interconnection Standard Clears Final Approval Hurdle.*** A key milestone was met when the IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems was approved by the IEEE Standards Board. The standard, which was published in early summer on a high-priority schedule, establishes the long awaited technical foundation to allow interconnection of all DG technologies to the electric grid. It also ensures that the return on federal and industry DG development investments will be realized. This standard will have a significant impact on how the energy industry does business in the future and will influence the way the electrical distribution system will operate with distributed generators and 2-way flow of electric energy.
- ***NREL Selected to Lead U.S. Participation in International Technical Committee.*** The Electricity Energy Supply Systems Technical Committee 8 (TC8) within the International Electrotechnical Commission's (IEC) scope is to prepare international standards or other deliverables necessary in an electricity open market to ensure the proper functioning of the electrical system considered as a whole, in coordination with other relevant Technical Committees. The IEC international standards support world trade; improve global industrial efficiency; provide the framework for economies of design, greater product and service quality, more interoperability, and better production and delivery efficiency; with all that leading to new markets and economic growth. Further, IEC conformity assessment and product certification schemes at the national level assure a certified product was manufactured and type-tested to well-established international standards. The end-user is assured the product meets quality standards and need not be concerned with further testing or evaluation of the product.
- ***Work on Standards that Complement 1547 Accelerated.*** Stakeholders identified a series of complementary IEEE 1547 standards needed on a fast track basis to effectively integrate DR technologies and to guide technology development for the grid of the future. On an accelerated schedule and accounting for tightening resources, virtual meetings were employed that significantly save travel expenses but increase coordination and planning efforts. NREL-hosted meetings to develop drafts of several IEEE interconnection standards: P1547.1 Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems; P1547.2 Application Guide for IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems; and P1547.3 Guide for Monitoring, Information Exchange and Control of Distributed Resources Interconnected with Electric Power Systems.
- ***Islanding Testing of GE Universal Interconnection (UI) Device Conducted.*** NREL, GE Global R&D, and Multinlin conducted islanding tests at the NREL

DER Test Facility on a prototype Universal Interconnection UI device being developed under an NREL subcontract. The UI was tested with a synchronous generator and connected to the NREL utility grid simulator and islanding RLC load bank. The GE UI was designed to use only passive anti-islanding schemes and testing showed that there is still a significant non-detect zone with this type of anti-islanding protection.

NREL Installs GE UI Equipment
At DER Test Facility

- ***Command and Control for Distributed Generation Systems Evolved.*** NREL subcontractor RealEnergy completed a report that describes their evolving command and control system. The report includes data on information and communications requirements, development of the command and control algorithms for optimal dispatch, development of codes and modules for optimal dispatch algorithms, testing the codes using simulated data, installing and testing the Energy Management Software, and dealing with contractual and regulatory issues.
- ***Distributed Energy Neural Network Integration System Developed.*** NREL subcontractor Orion Engineering Corporation made progress in developing a Distributed Energy Neural Network Integration System (DENNIS™) to aggregate a community of small, distributed generators into a larger virtual single generator capable of selling power or other services. The strategy of discretionary control action at the household level, spread across all controllers in the DENNIS™ territory, enables the aggregated community to present a flat load profile to the utility. Orion has developed and validated the Control Law Generator, which demonstrated the ability to extract more savings from a DG system than basic control strategies and using the predictive abilities of the neural network. Using a very limited data set from only a month of weather data, the networks managed to achieve 80% accuracy in classifying the day type based on inputs of insolation, temperature, barometric pressure, and time of day. Orion also reported that preliminary benchmarking studies showed that the DENNIS™ system significantly outperforms net metering and avoided cost in compensating residential DG customers for generated power.
- ***Distributed Utility Integration Testing Program Developed.*** A report prepared by Distributed Utility Associates describes a proposed test of the electrical implications of deep and diverse penetration of distributed energy resources (DER) into distribution systems. As distributed power becomes more commonplace, its electrical interactions become more important and more challenging to manage. This testing program attempts to anticipate electrical interactions and discover the problems and benefits that will result from the extensive use of DER. This report provides a good overview of DER and issues with high levels of penetration.
- ***Distributed and Electric Power System Aggregation Model and Field Configuration Equivalency Validation Testing.*** NREL subcontractor DTE completed a report on a study to determine the magnitude of distributed resources that can be added to a distribution circuit without causing undesirable voltage regulation, power quality, stability, or reliability conditions or equipment damage. This research into the interaction between DG and distribution lines is one example of the ongoing efforts to develop the data and analytical tools necessary to assess the reliability and performance of the transmission and distribution system, and promote the deployment of new transmission and distribution system technologies. The detailed modeling, simulations, and analyses presented in this report provide repeatable methods and procedures to evaluate the effects of DG as well as quantitative conclusions and recommendations concerning DG penetration limits and protection equipment requirements.
- ***Coated Superconductor Successfully Prepared.*** A Bi-2122 coated conductor prepared from electrodeposited precursors showed current density of 5 x 106 A/cm2 at 4.2 K. The film quality was studied by TEM which showed phase pure Bi-2212 with minimal defect densities. Two papers were published: 1. R. N. Bhattacharya, J. Chen, R. D. Blaugher, "Biaxially textured superconductor Bi-oxide films via an electrodeposition process," IEEE Trans. of Applied Superconductivity, volume 13, number 2, page 2496, June 2003. 2. R. D. Blaugher, R. N. Bhattacharya, and J. Chen, "Bi-2212: An HTS coated conductor," IEEE Trans. of Applied Superconductivity, volume 13, number 2, page 3343, June 2003.
- ***Testing of Liquid Desiccant Deactivation of Anthrax Spores Completed.*** MRI completed testing of spore deactivation at their BioSafety Level 2 and 3 labs.

Validation of NREL kill results and extension to actual Anthrax increases credibility of our findings of 99.99% bacillus spore kill. MRI anthrax results show accelerated Anthrax spore kill using liquid desiccant. MRI also completed analysis on electrostatic collection enhancement for sub-micron (spore-sized) particles. The literature and MRI experience indicate that ESP can be used with NREL's regenerable core technology to increase spore capture to HEPA filter levels of 99.97% and higher. The capture analysis provides NREL with an experimental ESP design it can implement in the lab and use to establish HEPA-level air filtration capabilities for our new liquid desiccant air conditioner.

- ***Initial Evaluation of Enabling Technologies Completed.*** Initial evaluation of an enthalpy exchange membrane indicates that it offers a 3-fold increase in moisture recovery relative to state-of-the-art fixed core enthalpy exchangers, making it comparable to rotating devices while eliminating moving parts. This reduces costs and maintenance and opens markets with drop-in applicability. These energy-saving capabilities are useful in buildings and are of particular interest to the PEM fuel cell industry for stack moisture management. Evaluation of a staged indirect evaporative cooler concept shows it is an excellent heat rejection complement to desiccant cooling. It can cool air below its wet bulb temperature, effectively doubling state-of-the-art capacity; this performance is unaffected by the high temperatures exiting the drying stage, making possible non-compressive total cooling systems with Seasonal Energy Efficiency Ratios over 20.

FreedomCAR and Vehicle Technologies

- ***Safety and Performance Assessment of E-diesel Completed.*** A study assessing the potential failure modes for vehicles operating on ethanol diesel blends (e-diesel) was completed. Notably, the analysis did not reveal any unanticipated issues. The potential for fuel tank ignition and vapor lock were the highest risks, and low to moderate costs solutions were proposed that reduce risks to levels similar to that encountered in using gasoline. The study confirms the potential of this fuel for practical use in centrally refueled fleets and contributes towards attaining DOE's petroleum displacement goals.

Destructive testing of e-diesel fuel tank without flame arrestor

- ***Fuel Cell System Modeling Capability Expanded.*** Significant improvements were made to ADVISOR™ fuel cell models. The vehicle speed has been linked to the heat transfer processes in the radiator and the condenser, and the fuel cell model equations were updated to include inlet ambient pressure as a variable. These improvements are significant because they allow the tool to analyze the impact of altitude and ambient temperature on fuel cell vehicle performance and fuel economy. This also relates to one of DOE's key technical barriers for fuel cells, which is thermal and water management.
- ***Energy Storage Options for Improving Fuel Cell Vehicle Efficiency Investigated.*** NREL evaluated the benefits and requirements of energy storage (batteries or ultracapacitors) for fuel cell hybrid vehicles using ADVISOR™. Analyses indicate that batteries or ultracapacitors could capture significant regenerative braking energy, which enhances the fuel economy of fuel cell vehicles. Component operating characteristics on an acceleration test compared favorably with those published on Honda's FCX vehicle. Preliminary results were presented to the Fuel Cell, and Energy Storage FreedomCAR technical teams. Industry representatives were pleased with the results and requested more results on component sizing, control strategy, and fuel economy benefits of ultracapacitors in fuel cell hybrid vehicles at the next meeting.
- ***Six Sigma Design Applied to Hybrid Vehicle Battery Thermal Management.*** NREL worked with the FreedomCAR energy storage technical team and Ford to apply six sigma design techniques to improve the thermal management of batteries for hybrid vehicles. Six-sigma design is the latest trend in the automotive industry for improving quality and robustness of products. It combines NREL's NiMH battery experience with computer-aided design tools and six-sigma design. Results from this analysis were discussed in a September meeting at Ford with the FreedomCAR energy storage technical team. The results will help FreedomCAR developers choose the best battery approach for their next generation HEVs.
- ***Team Develops Thermal Test Procedure for Benchmarking Batteries.*** NREL supported FreedomCAR Energy Storage to establish a standard for testing and benchmarking a battery thermal

management system for hybrid applications. NREL proposed a test procedure backed by experiments of Saft 48-Volt air-cooled and liquid-cooled modules. In September, the FreedomCAR Energy Storage technical team reviewed the proposed test procedure and provided feedback on finalizing it.

- ***Optimum Parameters for Battery Preheating Studied.*** To overcome the poor performance of hybrid vehicle batteries in cold climates, NREL assembled an experimental setup consisting of an alternating current (AC) amplifier, a battery cycler, an environmental chamber, and electronic interface. Tests were conducted at –30ºC for a prismatic NiMH battery. Parameters were studied for the eventual design of an on-board heater to overcome the cold cranking technical barrier.
- ***Study Presents Major Findings on Weekend and Weekday Differences in Ozone Levels.*** NREL co-authored several technical and summary papers in the Journal of the Air & Waste Management Association concerning results from a weekend ozone effects study in California's South Coast Air Basin (Los Angeles area). The study indicated that despite large reductions of hydrocarbons and nitrogen oxide emissions on weekends, weekend ozone levels are nearly identical to or higher than weekday ozone levels in many urban locations in the United States.

- ***Tests Show that Diesel Particle Filters Remain Effective Over Time.*** NREL tests of the Ralph's Grocery fleet indicate that diesel particle filters installed in 1999 continue to show emission reductions after four years of operation. The Ralph's project was designed to test 15 diesel-fueled delivery trucks using emission control diesel and diesel particle filters. Now, after almost four years of operation and more than 450,000 miles, the filters continue to show significant reductions in emissions.

- ***Study Shows Canadian Tar Sands Diesels Have Equivalent Emissions Performance.*** NREL completed a study showing that diesel derived from Canadian tar sands has properties such as emissions of nitrogen oxides and particulate matter that are identical to conventional diesel. The results support continued importation of tar sands crude and diesel from Canada into the United States, which may affect imports from other countries.
- ***Fischer-Tropsch Performance Exceed Goals.*** As part of a CRADA with the South Coast Air Quality Management District, NREL tested two identical 2002 Cummins engines equipped with exhaust gas recirculation technology and optimized for use with Fischer-Tropsch (F-T) fuel. Both engines met or exceeded project goals for emissions. The engines were tested using the Federal Test Procedure and resulted in reductions over the standards for NOx and PM. The engines also exceeded targets for NO2. NOx emissions were reduced by 15% with F-T compared to California diesel fuel. These tests show that the NOx reduction with F-T does not depend on engine age and technology. The project is a cost-shared collaboration with California regulatory agencies, Cummins Engine Company, and Shell.

Photo of a Cummins engine being tested

- ***Report Shows Benefits of Hydrogen-Natural Gas Fuel Mixture.*** NREL produced a milestone report that details the status of a project to develop and demonstrate hydrogen-compressed natural gas (HCNG) blend transit buses. Compared with a compressed natural gas (CNG)-fueled engine, the HCNG-fueled engine reduced emissions of nitrogen oxides (NOx) by 50%, non-methane hydrocarbons by 58%, methane by 16%, and total hydrocarbons by 23%. This was accomplished with no significant change in fuel efficiency between the HCNG- and CNG-fueled engines. The HCNG-fueled engine also maintained transient speed and torque capability. These results could be significant in defining a path from conventional transportation fuels to the new hydrogen economy.
- ***The ADvanced Automotive Manikin (A.D.A.M.) Gets a Brain and a Say in Thermal Comfort.*** The thermal comfort manikin, containing 126 individually controlled heated and sweating segments, can now be controlled by the numerical model of the human thermoregulatory physiological system. The complex finite element model receives heat fluxes from each of the 126 segments and calculates the resulting skin temperatures and sweat rates which are sent to the manikin. The model includes thermal conductivity, thermal capacitance, and heat generation for each element in the body. A network of pipes to simulate the human circulatory system models convection heat

transfer. Breathing is also modeled. The physiological model sends local skin temperatures to the psychological model that calculates local and global sensation and predicts local and global comfort.

- ***Thermal/Fluid Analysis Capabilities Support a Key Power Electronics Vendor.*** NREL used its thermal/fluid analysis capabilities to develop a more optimized heat exchanger package for a key power electronics inverter designed and built by Semikron. Semikron will adopt the new optimal design techniques suggested by NREL in their next generation inverter products. The more optimal heat exchanger opens the door for lightweight, compact inverter designs in advanced hybrid electric and fuel cell vehicles.
- ***Unique Class 4-6 Drive Cycle for Evaluating Heavy Hybrid Vehicle Performance Developed.*** NREL worked closely with Eaton Corporation and International Truck and Engine to develop a new, unique drive cycle (Composite International Local and Commuter Cycle) to accurately and cost-effectively evaluate Class 4-6 heavy hybrid vehicle performance benefits. This new drive cycle represents a new industry standard to judge Class 4-6 heavy hybrid performance and will be presented at both the SAE 2003 International Truck and Bus Meeting & Exhibition and in an official publication at the SAE 2004 World Congress.
- ***Development of Next-Generation Hybrid Electric Transit Bus Initiated.*** NREL initiated a project with GM Allison to develop the next generation electric drive unit and power electronics in the Allison EP system. The $5M, 32-month project will improve the system efficiency to result in a targeted 100% increase in fuel economy over a traditional diesel powered transit bus application. A kick-off meeting was held in June at the Allison Facility and a Program Implementation Plan meeting was held in July at DOE in Washington, D.C. A definitized subcontract was completed in September.
- ***Heavy-Duty Natural Gas Engine Approaches EPA 2010 Emissions Standards.*** The DOE/NREL Next Generation Natural Gas Vehicle activity supported development of a 12-liter Caterpillar engine with Clean Air Partners natural gas technology. The engine demonstrated oxides of nitrogen emissions of 0.5 g/hp-h and particulate matter emissions (PM) of 0.004 g/hp-h. By 2010, EPA will require NOxemission of 0.2 g/hp-h or less and PM emissions of 0.01 g/hp-h or less. The technology demonstrated in this project will help natural gas engine manufacturers meet these requirements.

Geothermal Technologies

- ***Ammonia-Water Condensation Experiments Completed and Data Transferred.*** There was a substantial effort to complete the ammonia-water condensation experiments with the data transferred to Heat Transfer Research Inc. (HTRI) for inclusion in their design codes. The most recent data transferred to HTRI is the process side heat transfer correlation for ammonia/water condensation at various inlet vapor concentrations.
- ***Technical Support Provided to GeoPowering the West.*** NREL provided significant input to the GeoPowering the West effort, including planning and support to organize and implement the National Geothermal Collaborative (NGC). NREL participated in a May meeting at the U.S. Forest Service (USFS) in Washington, D.C., on assessing renewable resources on forestlands. NREL identified leasing of geothermal resources on USFS lands as a barrier to be addressed by the NGC.
- ***NREL Supported IEA Direct Use Annex.*** NREL provides DOE-HQ support for International Energy Agency Geothermal Implementing Agreement activities by operating a common fund for 10 countries. A draft charter was developed by NREL for the Direct Use Annex.
- ***Research Advances Coatings Technology.*** NREL expanded PPS coating testing to other sites and more rigorous conditions. The first test of 40 foot-long tubes internally coated with PPS was started at Mammoth with exposure to production brine in June. That size tube is typically used at binary power plants and the ability to make a defect-free coating the entire length must be confirmed. PPS-coated steam vent pipelines at the Cove Fort plant showed no sign of attack from acidic condensing steam after 14 months of service. Tests of coated and uncoated tubes started at Puna in August. This is the first time tests were done at Puna, a high-temperature resource.A brine spray test of OMP-coated aluminum-finned steel tubing was started at Mammoth. This is the first test of the new OMP coating in exposure to brine spray. Tests of PPS-coated carbon steel pipe spools were started at a CalEnergy facility in the Salton Sea KGRA. The use of PPS-coated carbon steel well field pipe instead of problematic concrete-lined pipe could lead to major savings.
- ***Innovative Heat Transfer Concepts Improve Efficiency.*** NREL continued work on innovative heat transfer concepts, with transpired fins and with tabbed fins as well as with the fin-on-plate heat air-cooled condenser. The concepts are expanding the envelope of air-cooled condensation technology.

NREL completed and tested a modified fin-on-plate heat exchanger with a new vapor distribution system as well as two new sets of fins. Laboratory tests show that heat transfer coefficients are higher by as much as 80% (at higher velocities) compared to tube and fin configuration. Because of higher heat transfer coefficients, the surface area required is much smaller, therefore reducing the ground coverage by as much as 30%. NREL researchers have filed for a provisional patent on this new component. Three papers on the performance of this unit with steam, and ammonia/water mixtures were published. NREL researchers arranged for independent testing of the fin-on-plate heat exchanger by Intertek Testing Systems (ITS). The results of ITS tests compare very well with those of NREL. They are within 10% of each other.

- ***Tool Designed to Make Tabbed Fins.*** A tool was designed and fabricated for punching individual tabs into fin surfaces. Two small three-row test articles were prepared – five fins per inch and 10 fins per inch – and tested in NREL's transient test loop. Results showed ratios of heat transfer enhancement to pressure drop increase that is superior to louvered and wavy fins used by our industry partner, Super Radiator Coils. A provisional patent application for tabbed fin enhancements was submitted.
- ***Analysis of 1MW Plant Improves Design.*** NREL completed an analysis of a trim condenser and determined an optimum size for a proposed 1MW plant at Empire, Nevada. The analysis indicated that such a design would be marginally cost-effective, and NREL identified two ways to improve its performance: use of a mixed working fluid and use of an evaporative condenser. Results of an analysis indicated that a mixed working fluid could provide a significant reduction in the cost of delivered energy. NREL worked with Empire Energy and DOE to resolve final issues regarding continuance of the Empire design and prepared a contract modification that covers revision of the preliminary design and completion of a final design that utilizes a mixed hydrocarbon working fluid.

Hydrogen, Fuel Cells, and Infrastructure Technologies

- ***Reversible Inhibition of CO-Shift Process Studied.*** The biologically mediated water-gas shift reaction may be a cost-effective alternative to conventional technology for the conditioning of synthesis gas streams to produce additional hydrogen. The bioreactor must be operated at elevated pressures to achieve favorable process economics, but previous NREL results indicate that when the bioreactors are operated at elevated pressures, a reversible inhibition of the CO-shift process occurs. NREL developed a novel bioreactor design, the recirculating bubble column, and determined the causes of the inhibition. These results led to NREL's recommendation to conclude work on this pathway to hydrogen production.
- ***Photobiological Hydrogen Production Advanced***. Hydrogen-producing algae coproduce oxygen, which inhibits the hydrogen-producing enzyme. NREL showed that this oxygen inactivation can be limited by preventing oxygen accessibility through genetic engineering of the hydrogen-channel. By inserting a tryptophan side-chain, a physical barrier, or shield, is created that reduces the rate of oxygen diffusion into the active site. NREL designed a new system for continuous photo biological production of hydrogen by algae. Ten days of continuous production were demonstrated under sulfur-deprived conditions, more than doubling the production time of batch reactors.
- ***Understanding of Genes Enables H_2 Production***. NREL identified two additional genes involved in the water-gas shift (WGS) pathway in Rubrivivax gelatinosus CBS. Eleven of the 15 genes that are involved in WGS were completely sequenced at NREL. NREL demonstrated the ability to insert WGS genes of its choosing into CBS cells to make more of the H_2-production related proteins.
- ***Bench-Scale Production of H_2 from Waste Plastic.*** NREL demonstrated the production of hydrogen from complex waste plastics at the bench scale. Pyrolysis of polypropylene and catalytic steam reforming of the resulting volatiles over 10 hours produced hydrogen at 80 percent of stoichiometric conditions.
- ***Technologies For Producing Hydrogen From Biomass Advanced.*** NREL successfully tested a new support material for catalysts that resists: 1) attrition in a fluidized bed; 2) coking on the catalyst; and 3) formation of deposits at the point of injection of the biomass feedstock into the process. This allows gasification or pyrolysis of biomass to be extended for a significant period compared to previous technologies.
- ***Sustainability of Semiconducting Nitride Materials as Photoelectrochemical Water Splitting Devices Assessed.*** Two materials, InGaN and GaPN, showed high stabilities, and all of the InGaN samples had the appropriate band edge potentials to split water into hydrogen and oxygen in acidic solutions. NREL determined that either of these materials has the possibility of reaching the DOE near-term 2005 goal of 7.5% efficiency and 1,000-hour lifetime.

- ***Pressure Swing Adsorption Systems Evaluated***. In support of the Clark Atlanta University Biomass to Hydrogen project, NREL evaluated Pressure Swing Adsorption (PSA) systems for applicability to the biomass to hydrogen technology. Using the product vapor composition from the NREL tests and the 100-hour run in Georgia, NREL provided detailed specifications to Clark Atlanta and their partner, Eprida, for procurement of a PSA unit to be installed at the facility in Georgia.
- ***Conceptual Design of Bubbling Bed Reactor Completed.*** NREL completed the conceptual design for a 10x scale-up of the bubbling bed catalytic steam reforming reactor to 250-kg hydrogen per day capacity. This design will facilitate construction of a pilot-scale biomass to hydrogen system with better heat integration towards achieving the goal of 87% reforming efficiency.
- ***Hydrogen Storage Science and Technology Advanced***. NREL synthesized metal-tipped, multi-walled, carbon nanotubes by hot-wire chemical vapor deposition. Hydrogen uptake was increased due to carbon/metal synergy. NREL's theoretical calculations of hydrogen binding on boron substituted C_{60} showed an elongated H_2 bond length characteristic of non-classical hydrogen binding. This helps to explain enhanced storage of hydrogen. NREL scientists developed new calibration techniques for temperature programmed desorption apparatus that will enable rapid throughput measurements. NREL researchers implemented a fluorescence technique that enables the tube types in heterogeneous single-wall nanotube samples to be identified.

Senior scientist Mike Heben peers into desorption apparatus used to measure hydrogen storage properties of carbon materials.

- ***Modeling Results Correlated with Fuel Cell Experiments.*** NREL computer-aided engineering modeling results correlate with Plug Power experiments for fuel cell components, including stress and deflection in membranes for three fuel cell stack designs for stationary fuel cells and autothermal reformer – fluid flow.
- ***First Evaluation of a Prototype Fuel Cell Transit Bus Completed.*** NREL completed the first evaluation of a prototype fuel cell transit bus utilizing proton exchange membrane (PEM) fuel cells. The bus met or exceeded all of the goals set for the six-month demonstration. The results of this limited evaluation show a fuel cell hybrid propulsion system is capable of performing well in transit service.
- ***Critical Code Items Addressed.*** NREL hosted a meeting of the International Code Council's (ICC) Hydrogen ad hoc Committee in May to discuss and prepare proposed amendments to the ICC's 2006 code revision cycle. Several key items were included in the next set of proposed amendments that were discussed at the ICC public hearing in September. These items include provisions for underground storage of liquid hydrogen and storage of compressed gaseous hydrogen above fueling dispenser canopies. Both provisions are critical for hydrogen fueling infrastructure development.

Solar Energy Technology

- ***New Concentrator Cell Record Achieved.*** Spectrolab Inc., under a cost-shared NREL subcontract, continued remarkable progress in conversion efficiency records for a terrestrial concentrator solar cell. Previously, Spectrolab improved the efficiency from 34% to 35.2% under concentrated sunlight. This period, Spectrolab achieved 36.9% efficiency for a triple-junction structure, another significant improvement. This result builds on the NREL-patented two-junction device licensed by Spectrolab. In a related development in the High Performance PV project, NREL researchers identified a "signature" for the primary problem with GaInNAs, under investigation as a possible third junction in a four-junction device aimed at achieving 40% efficiency. The defect causes short minority-carrier lifetime in the material. This is a major step in developing techniques to eliminate this defect.
- ***NREL Leads in Application of Combinatorial Materials Science.*** This novel approach for high throughput research allows families of materials and combinations of materials needed for device structures to be rapidly explored. NREL completed experiments creating thousands of different compositions of dielectric films during this six-month period. Also, the combinatorial growth of a library of silicon thin-film samples helped to quickly "home-in" on optimum conditions for the material. NREL's leadership in this field is recognized by

invitations to lead conferences and symposia, such as the upcoming MRS conference.

- ***Progress in Thin-Film Tandem Cells.*** NREL demonstrated a prototype tandem using Si and CuGaSe2 (CGS) as the bottom and top cell absorbers, respectively. The CGS top cell was grown by elemental evaporation following the NREL-patented three-stage process. The interconnect junction consisted of an n+-ITO. Initial measurement showed excellent voltage addition of about 1.3 V, and efficiency of about 5.1%. NREL subcontractor, the Institute of Energy Conversion at the University of Delaware, developed a potential wide-bandgap cell based on Cu(In, Ga)(Se, S)2, with the best performance obtained for low S and high Ga contents. Cells were tested with an AR coating at NREL and were more than 10% efficient, meeting an important milestone for the High Performance PV project.
- ***Basic Science Research Advances Forefront of PV Technology.*** NREL, working with Rutgers University, reported unusual electronic properties of novel one-dimensional, two-dimensional, and three-dimensional inorganic-organic semiconductor networks with great potential for applications in areas of photovoltaic and solid-state lighting. A novel hybrid organic-inorganic (AnTe/Tetracene) superlattice structure was found to have properties that include a very strong quantum confinement shift that will be useful for novel solar cells and LED devices. NREL also found experimental evidence suggesting that dye-sensitized solar cell performance cannot be significantly improved by enhancing the electron transport rate. Before this study, there was considerable effort to improve the efficiency of dye solar cells based on the perception that speeding up electron transport would reduce the rate of recombination. Finally, computational materials research studies showed that n-type doping in CdZnTe, an important PV material, can be significantly enhanced as a consequence of mutual repulsion of two donor levels in the material.
- ***Progress in PV Manufacturing R&D.*** Several NREL subcontractors reported major technical progress in their manufacturing R&D projects. Energy Photovoltaics achieved a 10% gain in stabilized power output and a 30% reduction in direct manufacturing costs. ITN Energy Systems in collaboration with Global Solar Energy completed several modeling tasks supporting the advancement of CIGS module production. They developed physics-based and empirical models for deposition processing, implemented model-based control for CIGS processing, developed in-situ sensors, and applied predictive models to the construction of new evaporation sources for CIGS production deposition processes. Energy Conversion Devices completed an investigation of both chemical and plasma substrate cleaning processes resulting in an improvement in their production yield. They also developed closed-loop thickness control systems for the deposition of their ZnO, ITO, and a-Si component layers, as well as a PV Capacitive Diagnostic (PVCD) system for the measurement of the J/V characteristics of component cells in the triple-junction device. These in-line, real-time QA/QC tools are expected to make significant improvements when implemented at the Uni-Solar 30MW/yr manufacturing facility in Auburn Hills, Michigan. Finally, Specialized Technology Resources worked with BP Solar, Shell Solar, and Energy Photovoltaics in developing alternative, low-cost encapsulants for specific module types and end-use applications.
- ***Improved Concentrating PV Module Successfully Tested.*** Several Spectrolab concentrating photovoltaic (CPV) modules were tested at the NREL High Flux Solar Furnace (HFSF). Efficiencies (based on cell area and incident flux at the module plane) slightly over 30% were obtained, very close to test results at ideal laboratory conditions for a single cell. With further development in this area, Spectrolab will be in an excellent position to provide cells for CPV receivers. Spectrolab is interested in working under a CRADA agreement with NREL and Solar Systems Ltd. to develop cells for near-term dish applications.
- ***Optical Testing of Mirror Panels.*** NREL continued to provide optical characterization assistance to the CSP dish industry using our unique Video Scanning Hartmann Optical Test (VSHOT) system. This assistance included testing of dozens of Science Application International Corporation (SAIC) fixed focal length mirrored facets intended for use with Stirling or concentrating PV receivers as well as Stirling Energy System's (SES) facet design (produced by Paneltec Corporation) intended for use with their 25kW Stirling systems.
- ***PV System Testing Standard Approved.*** The IEEE-SA Standards Board Review Committee approved IEEE P1526, "Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems," as a new recommended practice. The new standard provides procedures that independent testing laboratories will use to evaluate the performance of stand-alone PV systems. In the United States FSEC was approved by Powermark Corporation to provide certification testing for PV systems, and plans on using P1526 to certify PV system performance. P1526 is also the basis for international standard, IEC 62124,

"Photovoltaic Stand-Alone Systems – Design Qualification and Type Approval." Work on P1526 was based on validation testing conducted on stand-alone PV systems at NREL, Sandia, SWTDI, and FSEC over the past five years.

Wind & Hydropower

- ***Lamar Low-Level Jet Project Yields Initial Results.*** NREL published a technical report, entitled The Lamar Low-Level Jet Project Interim Report, which presents the experimental results to date of a collaborative effort between DOE, NREL, and GE Wind Energy. The purpose of the project is to develop an understanding of the influence of nocturnal low-level jet streams on the inflow turbulence environment and to document any potential operating impacts on current large wind turbines and the Low Wind Speed Turbine designs of the future. A year's record of detailed turbulence measurements were collected from NREL instrumentation installed on the GE Wind 120-meter tower in southeast Colorado and supplemented with mean wind profile data collected using an acoustic wind profiler or SODAR. The FY02 Peer Review Panel identified this research activity as a high priority and felt that NREL should accelerate characterization of events like those caused by the nocturnal jet.

GE Wind 120 meter meteorological tower South of Lamar, Colorado

- ***Advanced Drive Train Testing Initiated***. NREL began testing three advanced drive trains optimized for low wind speed applications. The advanced drive trains that are being developed under Low Wind Speed Technology public/private partnerships will be tested at the NWTC 2.5MW Dynamometer test facility in FY03/04. Testing of the Clipper Windpower's 1.5MW distributed generator drive train (DGD-1) is underway at the NWTC and will continue into the fall. Innovative 1.5MW drive trains designed by Global Energy Concepts and Northern Power Systems are currently being built and are undergoing acceptance testing at the vendors' facilities and will be tested at the NWTC immediately following the Clipper test.
- ***Testing and Field Verification of Small Turbines.*** NREL published 13 test reports on three different small wind turbine models that are installed and operating at different sites throughout the United States. The small turbine tests, conducted at the NWTC, included power performance, noise, duration, and safety and function testing in accordance with domestic and international standards. NWTC test results are available for comparison against the manufacturer's specifications and performance data collected at the FVP sites.

Analytic Studies

- ***Distributed Power Technology Characterizations Completed.*** NREL led a collaborative effort to produce technology characterizations for six distributed power technologies. This consensus information on the current and projected performance and cost characteristics for these technologies is critical for both energy systems analysis and technology program planning purposes. The development of these characterizations is complete, and the results will be published and made available on the Internet.
- ***Analytical Support Provided for GPRA Projections.*** NREL prepared process guidance for EERE's development of GPRA projections for the FY2005 budget submission, and is working with EERE to develop the projections that are a key element of EERE's communication of the prospective benefits of its programs.
- ***Power Technologies Databook Updated.*** NREL completed an update of the Power Technologies Databook that provides current information on electricity sector resources, technologies and markets, and the EERE technologies and programs relevant to that sector. It is available at nrel.gov/analysis/power_databook/
- ***Distributed Energy Database Developed.*** NREL completed development of a Distributed Energy Resources database that merges information from other sources and provides a current, accurate summary of DER systems in place today.
- ***Renewable Power System Database Updated.*** NREL completed an update of the REPiS database on renewable power system projects to include information through 2002. This database is valued by DOE, EIA, and external stakeholders as being the most definitive source for information on grid-connected renewable energy systems.

PO 1.4 Effectively communicate and transfer NREL-developed knowledge and technology.

PI 1.4.1 Private sector partnerships have been developed for commercialization of NREL technologies.

PI 1.4.2 Meet or exceed established technology transfer metrics.

PI 1.4.3 Quality communications products are developed and recognized as supporting the advancement of Program goals.

Assessment Summary

MRI and its integrated team of Battelle and Bechtel continued to provide appropriate stewardship of DOE-sponsored, Laboratory-originated knowledge, technology, practices, tools, materials, and/or processes. This stewardship included managing knowledge from its creation through its transfer to other for their use. NREL-developed knowledge and know how was transferred through a record number of publications, through technical assistance to domestic government organizations and international organizations, and via a variety of partnerships with the commercial sector.

Through its role in the Federal Energy Management Program (FEMP), NREL transferred technical knowledge of renewables to support a record number of federal facility energy projects. NREL has enabled the government sector to increase its use of renewable energy by more than 300% in less than four years. During the period, technical assistance was provided to more than 160 energy projects that save nearly 500,000 kWh annually. Through its role in the Weatherization and Intergovernmental Program (WIP), NREL addressed significant barriers to the use of energy efficiency and renewable energy in international markets, at the state and local level, and by tribes.

New relationships were developed with industrial partners to transfer NREL knowledge and know-how, including three major CRADAs in bioenergy research with DuPont; BROIN and ABENGOA are still in negotiation. Increased industry participation in enterprise development programs and the outcomes resulting from these novel approaches to catalyze support for clean energy start-ups are evidence of their increased visibility and impact.

In addition, the Laboratory continued to work to enhance the effectiveness of its technology transfer processes by improvement of key processes, adding staff capabilities and training, and by acting on opportunities identified. Of particular note, NREL was presented a special award by the Federal Laboratory Consortium in recognition of the Laboratory's long-term efforts to facilitate the use of renewables to safeguard the nation's energy infrastructure.

Technology Transfer Highlights

Technical Assistance Enables Energy Projects

Through both FEMP and WIP, NREL served as a technical advisor and partner to other agencies in defining technical requirements of energy projects, evaluating options, and ensuring selected options meet their design specifications. Key highlights include:

- ***Technical Support to Projects Saves Energy and Reduces Costs.*** NREL far exceeded its project goal by supporting 163 federal EE/RE projects (goal was 80) this fiscal year. From these projects, $168M (goal was $50M) in new energy efficiency and renewable energy equipment was awarded to be installed at federal facilities through ESPC and UESC technical assistance. These projects result in 1,680,000 million BTUs or nearly 500,000 kWh saved annually at these sites. This equipment will save approximately $20.7M in taxpayer dollars annually.
- ***Onsite Renewable Projects Move Agencies Closer to Goal.*** NREL provided technical assistance to 43 onsite renewable projects (goal was 25) and nine renewable power procurement efforts. NREL's efforts supported FEMP in its goal to assist agencies in achieving the Executive Order goal of all agencies getting 2.5% of their electricity from a renewable source by the year 2005. At the end of FY03, the federal agencies were over 50% of this goal, compared to 14% two years ago and 26% onr year ago.
- ***International Project Assistance.*** NREL facilitated use of EERE technologies in several countries. For example, in Mexico, NREL developed a wind atlas for the state of Oaxaca showing 33,000MW of wind potential in the Isthmus region alone. Continued ESCO project facilitation has resulted in the first successful commercial financing of an ESCO

project in Mexico and a new ESCO partnership between a Mexican ESCO and Ameresco. In Brazil, NREL conducted evaluations & prepared technical reports for the Joanes and Campinas hybrid systems that have catalyzed local action to refurbish and replicate them.

- ***Tribal Energy Projects Supported.*** NREL provided technical assistance to the Sealaska and Bristol Bay tribes in Alaska, and to the Ramona and Manzanita tribes in California on anemometer siting and initial tribal capacity building regarding wind development. Biomass technical assistance was provided to the White Mountain Apache in Arizona, and the Choctaw in Mississippi.

Partnerships Enable Commercialization

Several significant partnerships were formed that will provide a key means of transferring knowledge and know-how. In addition, ongoing collaborations are leading to significant market impacts. Examples include:

- ***Natural Gas Engine Displaces 9.6 Million Gallons of Petroleum-Based Fuel.*** NREL collaborated with Cummins Westport, Inc. and other partners to develop the C-Gas Plus natural gas engine. In the first 20 months since production of the C-Gas Plus began, 1,044 engines were sold or ordered for use in transit buses in the United States. This represents approximately 9.6 million gallons of diesel fuel displacement annually, or 1.5% of the total U.S. annual diesel fuel consumption by transit buses. Vehicles equipped with the C-Gas Plus engine reduce some regulated emissions compared to conventional diesel counterparts.
- ***Three Major Biomass Program CRADAs Advanced.*** Several complex agreements were negotiated to allow NREL to work with three industrial partners awarded contracts under a DOE Office of Biomass Program solicitation. These agreements represent an overall DOE/NREL cost share of approximately $11.2M. DuPont de Nemours Company and NREL successfully negotiated a CRADA, FIA/WFO, and a license agreement. Abengoa Bioenergy Corporation and NREL are actively negotiating a CRADA along with the SOW. Additionally, Abengoa Bioenergy Corporation requested that critical terms of a license agreement be determined in parallel with entering into the CRADA. Broin & Associates and NREL have completed negotiation of a CRADA. Each of these partnerships is focused on critical aspects of a future biorefinery.
- ***Transfer of Diagnostic Tools Completed.*** GT Solar, Nashua, New Hampshire, licensed the NREL-developed *PV Reflectometer* technology and has initiated commercialization efforts. Due to its high-speed measurement capabilities, it is perfectly suited for the characterization of photovoltaic materials and finished solar cells in a production line environment.
- ***Partnerships Support Thin Film Commercialization.*** NREL's CRADA with Hewlett Packard was extended for an additional 12 months with $330K funds-in along with delivery of a $60K tool for reactive ion etching for use at NREL. This research will help to establish the infrastructure for thin-film manufacturing that can support both PV and micro-electronic applications. NREL also negotiated a CRADA with AKT, Inc. to adapt commercial thin-film production tools for PV processes. This partnership could provide predictable thin-film processes to U.S. businesses interested in PV.
- ***Collaborations Improve Battery Performance.*** NREL initiated collaboration with ElectraStor to improve their nickel hydrogen batteries. NREL evaluated, developed, and screened anodes and cathodes for this potentially high power, high-energy battery. This work supports the development and validation of batteries that can meet heavy hybrid vehicle technical targets. NREL used thermal characterization tools (calorimeter, infrared thermal imaging, and computer aided design) to provide technical support to Compact Power to improve thermal performance of lithium ion polymer gel batteries in three generations of cells. Improvements in third-generation cells have resulted in more uniform temperature distribution, lower maximum temperature, and less heat generation, all of which are needed for a more energy efficient and longer life battery operation.
- ***Wind Airfoil Licenses Respond to Market Pull for Replacement Blades.*** NREL negotiated licenses with two small businesses for the use of NREL's patented wind airfoil technology. These licenses help ensure a cost-competitive supply of blades to existing wind farms, and support small business success in renewable energy.
- ***WFO Project Shares Knowledge from Geothermal Program.*** NREL is funded via work for others to assess desalination of seawater using techniques developed for direct contact condensation within the Geothermal Technologies Program.

Enterprise Development

NREL continued to work to remove barriers to commercializing clean energy technologies via start-up companies. Key highlights include:

- ***Partnerships Established for 16th Industry Growth Forum.*** NREL received commitments for $125K in contributions for the upcoming 16th Industry Growth Forum, planned for November in Austin, Texas. The financial leverage attests to the value of this event significant to investors, clean energy companies, and interested stakeholders. NREL also instituted a new, Web-based process for clean energy company applications to the Forum, saving time for both applicants and reviewers. More than 100 companies have applied for the 35 presentation slots available.
- ***NREL Growth Link Expands Investment Networking with Clean Energy Companies.*** Growth Link is a web-based directory of clean energy companies seeking financing, partnering, and growth opportunities. Investors and energy firms can use the directory to find clean energy technologies that match their investment and strategic interests. Growth Link also provides a method for networking/connecting incubators, clean energy companies and investors, and gives each of these players additional exposure to the others. Participation is growing and has reached 150 companies.
- ***National Alliance of Clean Energy Business Incubators Exceeding Expectations.*** In the past two years, the organization has grown, attracting 10 of the nation's top incubators who are now committed to incubating and providing business services to clean energy entrepreneurs. Market performance and value of the Alliance is exceeding the expectations that were established at the beginning of the collaboration. Specific outcomes that have been achieved include:
  - Eighty companies are now in Alliance incubators
  - Approximately 1,000 jobs were created and supported by these companies
  - $5M in private capital was raised for the companies
  - $5M in state and local funds to the incubators significantly leverages the funds that were invested by DOE
  - Three companies have graduated from the incubators and are positioned for market success. NREL has successfully integrated the Alliance into other complimentary Enterprise Development activities to the mutual benefit of all partners.

Removing Information Barriers

NREL used a variety of mechanisms to transfer technical knowledge that enables consumers make informed energy choices. As examples:

- ***Vehicle and Fuel Information Provided to Stakeholders.*** NREL provided updates and additions to the information resources for Clean Cities coordinators, stakeholders, and fleet managers. New Web-based information in the Alternative Fuels Data Center on niche markets, fueling stations, funding resources, K-12 educational resources, and comparative fuel data addressed the most pressing needs for information identified in last year's Information Needs Assessment report. In addition, NREL completed total redesign of the Fleet Buyers Guide, an on-line tool that helps fleet managers identify applicable regulations and financial incentives, select appropriate vehicles and compare costs, find local fueling infrastructure, and access industry contacts and resources.
- ***Knowledge Transferred to Federal Energy Managers.*** NREL transferred its extensive knowledge and experience with technical solutions and best practices to federal energy managers and industry personnel to address their energy needs by presenting information to 3,100 people (goal was 2,000) through 81, technical workshops, and agency meetings. This far-reaching effort is indicative of the Laboratory's extensive knowledge and experience with the program; resulting in technical assistance with solutions and best practices that helps energy managers and industry personnel meet their energy needs.
- ***Labs for the 21st Century Gaining Momentum.*** NREL completed two case studies, five lab design courses, three best practice guides for laboratory design; design assistance on four new laboratory facilities, including NREL's Science and Technology Facility; a student design competition for a sustainable lab; and a parametric study of energy savings in four climate zones. These efforts contribute to the Labs for the 21st Century Program gaining momentum within the federal sector.
- ***Technical Assistance Provided to Clean Cities.*** NREL managed the delivery of Tiger Team technical assistance for several airport projects, a CNG fueling facility, and assisted coalitions with legislative, business development, and air pollution issues.
- ***Information Transferred to Educational Institutions.*** NREL published The Energy Smart Guide to Campus Cost Savings and distributed more than 800 copies of these guidelines to college and university officials. NREL delivered expert technical assistance for the design of the Baltimore Aquarium, and the Heritage Harbor Museum in Providence, Rhode Island.
- Renewable Energy Training Curriculum Prepared and Distributed. NREL developed a comprehensive training curriculum on renewable energy

technologies, applications, policies and programs for government officials and other stakeholders in developing countries. NREL worked with DOE, UNEP, AID, EPA, and others to disseminate and apply this curriculum in training around the world. NREL also provided weeklong training on Homer to 12 developing country partners.

- ***NREL and Regional Office Educate State Officials.*** NREL collaborated with DOE's Denver Regional Office and the National Conference of State Legislators in organizing and hosting a Renewable Energy Seminar for state legislators and state energy officials. More than 40 state officials from the Denver Region were exposed to a range of renewable energy technologies through informative presentations and hands-on demonstrations. Positive and effective results are already evident. Oklahoma organized a major wind power event attended by various state interests including regulators, legislators, developers, and manufacturers. The agenda included discussions on increasing the development of wind within the state, transmission, and Renewable Portfolio Standards (RPS).
- ***Expert Technical Assistance and Handbook for Tribal Energy Program.*** NREL prepared a draft Tribal Energy Guide to assist tribal officials in developing energy programs and policies and understanding the full potential for use of EERE technologies on tribal lands.

External Recognition

NREL expertise and leaderships in technology transfer was acknowledged by external awards, elections, and visibility.

- ***NREL Received Special Federal Laboratory Consortium (FLC) Award.*** The FLC Mid-Continent region recently honored NREL with an award for Outstanding Technology Development in recognition of the Laboratory's long-term efforts for "*Using Renewables to Safeguard the Energy Infrastructure of the U.S.*" This award recognizes the outstanding work of all Laboratory staff and enhances NREL's visibility within the FLC.
- ***Technology Transfer Office Director elected to DOE Technology Partnerships Working Group (TPWG) Executive Committee.*** The Executive Committee serves as the liaison and point of contact for communications among representatives from DOE-HQ, DOE field offices, and DOE facilities on technology partnership topics. The position will allow NREL to exert more leadership toward increasing the effectiveness of technology transfer in the DOE system.
- ***NREL Technology Commercialization Report Deemed Valuable.*** NREL's report entitled "Bridging the Valley of Death: Transitioning from Public Sector to Private Sector Financing," was coauthored by a member of the venture capital industry. The DOE TPWG found the report so insightful that it was distributed to all DOE laboratories, and a presentation of the findings placed on the agenda for the annual TPWG meeting. The report will lead to enhanced credibility for NREL and increased understanding of the importance of financing issues and their resolution.

Technology Transfer Process Enhancements

NREL maintained its commitment to continuous improvement through process enhancements and development of tools that enable technology transfer.

- ***Intellectual Property Framework Developed for Multi-Participant Virtual Center.*** As part of a response to a DOE competitive solicitation, NREL developed an intellectual property plan and negotiated its approval with the seven universities, three federal laboratories, and a private sector entity that are part of the virtual center team. This model will facilitate the development of other virtual centers in the future.
- ***NREL Develops Process for Qualifying Potential Licensees.*** Negotiating licenses with partners who are not well-qualified to commercialize the technology can waste significant amounts of time, and potentially result in good technology that is tied up with an ineffective partner. NREL has developed a new process for completing due diligence on all partners that are interested in a licensing agreement. The approach has led to reduced execution time for two licenses, and resulted in quick termination of discussions with three interested parties.
- ***NREL Develops Two Technology Transfer Databases.*** The Negotiations Status Report (NSR) database tracks all ongoing license negotiations at the Laboratory, resulting in better coordination of limited resources and faster execution of licenses. Another database tracks our licensing accomplishments using guidelines developed by DOE for technology partnership programs, and ensures we can rapidly comply with DOE requests for information.
- ***License Administration Process Gets Results.*** The overhaul that NREL made to its process for administering existing license agreements continued to yield results. We have moved from a licensee compliance rate of less than 75% to 94% today. The single license that is not in compliance has an action plan aimed at bringing it into compliance.

- ***Critical Training in Intellectual Property Management Elements Provided.*** A training and orientation session on patent management software (PATTSY) was provided for Laboratory intellectual property/technology transfer staff members, who need to manage dates for filings and payments to assure integrity of intellectual property process. The Patent Counsel provided training on the legal aspects of the inventor's role to the National Bioenergy Center staff. In addition, a briefing to NREL senior management was provided on the legal sufficiency of electronic laboratory notebooks for protecting Laboratory intellectual property. The briefing was responsive to the issuance of the DOE draft guideline pertaining to the possible future use of electronic notebooks within the DOE laboratory complex**.**

- ***Standardized Metrics for Transferring NREL Technology.*** The Laboratory monitors several "standard" technology transfer metrics over time to gain a balanced perspective on the activity level and associated benefits. Regular evaluation has resulted in a number of enhancements over time including those discussed in the table below, and in previous reports..

Standardized Metrics for Transferring NREL Technology

	FY01 Total	**FY02 Total**	**FY03 Total**
Publications	910	1048	1116
Record of Inventions	52	35	34
Patent Applications (includes U.S., Foreign, PCTs)	68	81	49(1)
Licenses	2	6	6
Active Licenses	30	25	26
FIA/WFO	23	29	28
New CRADAs	10	11	7
$TPA	$10,541,390	$9,488,869	$9,007,000

(1) The decline in patent applications for FY03 is related to the decline of Records of Invention between FY01 and FY02.

CO 2.0 Leadership – MRI will lead NREL as an FFRDC to create opportunities that significantly advance the EERE mission while enhancing NREL's role as a recognized national and international asset.

NREL Proposed Grade: Outstanding

PO 2.1 Provide technical leadership and input to the development of new opportunities.

PI 2.1.1 Ideas, analysis, and other input from NREL impacts/influences the strategic direction of DOE program or business strategies.

PI 2.1.2 Participation in technical and other forums influences national priorities, policy, or program directions.

Assessment Summary

MRI and its integrated team of Battelle and Bechtel continued to provide leadership that strengthens NREL's role as a Federally Funded Research and Development Center (FFRDC) in support of the EERE mission. For example, NREL was asked to take on the role of Systems Integrator for the DOE Hydrogen Program. Working closely with DOE, and with assistance of MRI and Battelle, NREL laid the groundwork to establish the capability and develop an integrated baseline for the program. NREL conducted strategic analyses that provide a foundation for EERE program, policy, and portfolio development and/or inform stakeholder decisions among technology options. For example, multiple analyses were completed that have supported the development of technical targets within the Hydrogen, Fuel Cells, and Infrastructure Technologies and FreedomCAR and Vehicle Technologies programs. NREL provided technical leadership in defining new opportunities and future directions, such as a collaborative state technical assistance program to be delivered via the regional offices, a vehicle power electronics R&D roadmap, and thermal storage R&D needs. By convening or providing leadership in key forums, NREL has had an influence in informing decisions.

Leadership Highlights

Systems Integration Leadership

NREL worked closely with the DOE Hydrogen Program manager and with the EERE DAS to launch the effort to establish a systems integration capability at NREL that will initially be applied to the Hydrogen Program and ultimately to other programs in the EERE portfolio. This effort was launched in early May in a meeting with EERE and GO principals, MRI, and NREL executive management. Progress made since that meeting includes:

- ***Systems Integration Director Position Defined and Candidates Identified.*** The position was posted in June and between responses to the posting and networking by MRI and Battelle, more than fifty resumes were received. Phone interviews of leading candidates were held and in person interviews were initiated. It is expected that a well-qualified director will by hired within the first quarter of FY04.
- ***Interim Capability Established.*** NREL established a transition team to define and begin implementation of the systems integration function. The team is comprised of NREL staff who were temporarily reassigned along with experts and advisors from MRI, Battelle, and other outside consultants.
- ***Systems Integration Function Defined.*** An initial 'charter' describing the function, role, responsibilities and authorities of the systems integrator was developed and reviewed by DOE. NREL sought input from across the DOE Hydrogen Program during the development of the charter and tapped expertise at Battelle and in the commercial sector to prepare early drafts of the charter. MRI, Battelle, and the NREL National Advisory Council reviewed these drafts. In addition, NREL closely coordinated development of the charter with the development of the DOE Hydrogen Program Management and Operating Plan that was developed by TMS. In addition to the charter document, a briefing package was prepared for DOE to support discussion of the function with external groups.
- ***NREL Supported Successful Meeting with NRC.*** The Laboratory director and interim systems integration director joined the DOE Hydrogen Program manager in a meeting with the National Research Council to discuss the role of systems integration. Subsequent informal discussions have

also been held with individual members of the NRC panel to keep them apprised of progress. Feedback indicates that the NRC is pleased with the rapid progress in establishing the capability and is comfortable with the direction that is being taken.

- ***Multi-Year Systems Integration Plan Developed.*** The charter was expanded to include milestones and deliverables through 2015 that align with the DOE Hydrogen Program RD&D plans. For example, the role of the systems integrator in providing critical support to key go/no-go decisions and technology down selections was highlighted.
- ***Progress Made Toward Establishing Baseline.*** NREL implemented level-1 milestones and deliverables from the HFCIT multi-year RD&D plan through project management software to enable quickly assessing relationships between tasks and to associate work scope and budget to facilitate impact analyses under varying budget scenarios. This will greatly streamline what was a manual process and serves as the precursor for the program baseline.
- ***Preliminary Planning Conducted to Define Macro-Systems Model Requirements.*** NREL developed a framework for describing the role of the macro-systems model in facilitating the validation and maintenance of the integrated baseline as well as its relationship to other types of models. Preparations were also made for an upcoming roundtable involving participants from the DOE Hydrogen Program, PBFA, and EIA that will focus on defining the requirements of the macro-systems model from multiple perspectives.

Strategic Analysis Leadership

Strategic analyses illuminate opportunities or issues, provide a basis for making program direction or policy decisions, and enable tradeoffs among energy alternatives. Examples of strategic analyses conducted during the period and its role in informing a variety of decisions include:

- ***Foundational Hydrogen Analyses Completed.*** NREL completed an analysis of distributed methanol reforming for hydrogen delivered at lower cost to customers at fueling stations; the water gas shift process, indicating limited economic potential; and the continuous production of hydrogen from algal photobiological processes. The Lab provided the hydrogen analysis group, H_2A, reporting and cash flow analysis spreadsheets for use in FY04 efforts, as well as economic analysis for inclusion into technical target tables in the Hydrogen, Fuel Cells and Infrastructure Technologies' multi-year research, development, and demonstration plan. The Lab conducted analysis on integrated wind/hydrogen systems, including component modeling and market adoption, and expanded earlier analyses to incorporate new data on hydrogen production from biomass. A technology brief on the ways in which to produce hydrogen from biomass was developed, delivered to the Biomass Program, and used in stage-gate analysis and review.
- ***National Mobile Air-Conditioning Fuel Use Estimated.*** 233 automotive climate control experts at the 2003 Alternate Refrigerant Systems Symposium discussed future mobile air-conditioning systems. NREL presented updated results on behalf of DOE and EPA. The updated analysis shows that the United States uses 7.0 billion gallons of fuel annually in light-duty vehicles to operate the air conditioner. This is equivalent to 5.5% of our national fuel use or 9.5% of the imported crude oil. NREL's analysis of indirect generation of CO_2 from automotive air conditioning fuel use was well received because of the increased global regulation of CO_2 emissions.
- ***Analysis Support Leads to Revision of Technical Targets.*** NREL provided input to the FreedomCAR Hydrogen Storage Tech Team, and achieved consensus among industry and DOE to separate Fuel Cell and hydrogen storage targets. Inconsistencies were identified by NREL between the FreedomCAR hydrogen storage targets and the fuel cell integrated system targets (which included hydrogen storage). ADVISOR™ was used to calculate how each of the two sets of targets could be modified to achieve consistency. The final recommendation was that keeping the two sets of targets unique and independent was the best solution.
- ***Fuel Consumption Penalty Associated with Cold-Start Illuminated.*** The prediction of the fuel economy impact of cold-start on reformed gasoline fuel cell vehicles provided DOE with input to its upcoming 2004 go/no-go decision on continuing research on reforming gasoline on-board vehicles to generate hydrogen. NREL found that if DOE's fast-start reformer targets are met for 2005 and 2010, the fuel consumption penalty would be between 15-30% (compared to 6-8% for vehicles powered by gasoline, internal combustion engines).
- ***Potential Role of Renewables in Air Quality***. Efforts in improving the understanding of the potential role of clean energy technologies in enhancing air quality are leading to important results on a number of fronts. NREL provided EPA with a report on "Alternatives for Evaluating the Emissions Impacts of Energy Efficiency and Renewable Energy Measures" for use in state and local environmental policy and program

formulation. More broadly, an analytic framework was developed to help state and local officials to evaluate the effects of renewable energy and energy efficiency in air quality efforts. The Central Ohio Clean Cities Coalition was provided with information on the emissions from various fuel/vehicle technologies, including diesels using regular or low-sulfur fuel, natural gas vehicles, and gasoline vehicles. NREL has established strong working relationships with EPA in this area and received funding support in FY03.

- ***Analytical and Strategic Support Provided for CSP 1000MW Initiative.*** NREL supported a series of meetings with the Western Interstate Energy Board (WIEB), state economic and energy policy advisors in Nevada, Arizona, and New Mexico, and energy staff at the Western Governors' Association (WG) annual meeting. The objectives were to present an analysis of the economic, energy, and environmental benefits of developing the states' solar resources and to solicit each state's interest in participating in the development of 1,000MW of concentrating solar power systems. The meetings have successfully maintained state support for the CSP.
- ***Technical Support of SolarGenix Proposed 50 MWe CSP Plant.*** The Nevada Public Utilities Commission approved solar energy contracts between Nevada's electric utilities and the Eldorado Solar Electric Generating Station (ESEGS) under development near Boulder City, Nevada. The ESEGS will generate enough electricity in 2005 and 2006 for both Nevada Power and Sierra Pacific Power to comply with the solar portion of Nevada's Renewable Energy Portfolio Standard. NREL staff provided significant support to SolarGenix before and after the power purchase agreement (PPA) was approved. This support included analysis of the solar resource at the proposed site, analysis of designs to minimize water use at the proposed site and use of NREL-developed systems analysis tools in support of the SolarGenix proposal. NREL staff provided similar support for the 1MW ORC plant built in Arizona.
- ***Analysis Informs Go/No-Go Decisions.*** Based upon analysis and data, NREL recommended to DOE an "off-ramp" and cessation of research on bacterial water-gas-shift reaction.
- ***Technical Analysis Identifies Opportunities for Restructuring Clean Cities Program and Integration with Hydrogen.*** The Lab conducted analyses and stakeholder consultations that identified the benefits to DOE of expanding the portfolio of technologies and tools that Clean Cities coalitions can pursue in displacing petroleum and meeting local needs. This analysis is helping shape the future direction of the program. An outgrowth of this analysis has been increased collaboration across several programs and activities at NREL with involvement in projects related to the near-term application and transition to hydrogen in the transportation sector. NREL staff have begun a project initiated by the Hydrogen Program to develop detailed geographic data and maps using data on fleet location, fueling infrastructure, and other information developed and maintained in the Alternative Fuels Data Center. A paper was prepared that identified opportunities for application of the alternative fuels physical infrastructure and Clean Cities institutional infrastructure to support the Hydrogen program.
- ***Analyses Support Geothermal Program Planning.*** NREL provided the Geothermal Technologies Program with updated assessments that show the potential of various activities within the program to impact goals and objectives. This work informs the strategic direction of the Geothermal Technologies Program. For example, NREL completed research and analysis on the cost and availability of water for evaporatively enhancing air cooled condensers and updated the Geothermal Component in the National Energy Modeling System.
- ***Analysis Supports Planning for Solar Initiative.*** NREL played a lead role in analysis of the implications of a potential solar energy initiative aimed at replacing 50% of the nation's building sector energy use by 2050. Understanding the form that such an initiative might take, as well as its potential costs and benefits, is essential to its consideration

Developing New Initiatives Opportunities Leadership

- ***Solid State Lighting Initiative.*** NREL catalyzed and co-authored a white paper with Sandia, Berkeley, PNNL, Los Alamos, and NIST that was provided to EERE. The paper summarized the resources of the national labs related to solid-state lighting research, and helps DOE determine what the labs role might realistically be in a DOE program to hasten the development and application of energy-efficient, solid-state lighting. Suggestions on how to structure the DOE SSL Program was provided. Based on a review of the Lab's capabilities and SSL program needs, NREL launched a DDRD project to explore new concepts in organic light emitting diodes (OLEDs). This initiative is creating an understanding of how the significant DOE

investment in photovoltaics technologies and capabilities can be leveraged to create breakthroughs in solid-state lighting technology.

- ***Integration of Fuel Cells in Buildings.*** Through this initiative, NREL developed a strategy for future R&D on optimum integration of fuel cell technologies in building CHP systems. The initial meetings and discussions with potential industry partners, and the preliminary review of the existing activities, have led to realization of the critical role the Lab can play in addressing major issues, such as waste heat utilization, system integration, and fuel diversity for fuel cell systems. A joint effort between NREL and AIL Research was initiated to evaluate waste heat recovery from low-temperature fuel cells. Proposals were submitted to the State Technologies Advancement Collaborative (STAC) to conduct laboratory research on fuel cell-based CHP systems and to develop testing protocols for fuel cells/CHP. A proposal was also submitted for consideration in the FY04 HFCIT AOP.
- ***Multi-Year Vehicle Power Electronics R&D Roadmap Developed.*** NREL lead the R&D plan efforts to develop an Advanced Power Electronics R&D plan roadmap. The Lab worked closely with the FreedomCAR EE technical team and Oak Ridge National Laboratory to establish the multi-year technology roadmap to guide DOE's power electronics R&D out to 2015. This roadmap will serve to guide for DOE's R&D multi-year planning and budget formulation and for executing national laboratory efforts, and subcontracts on the Advanced Power Electronics program.
- ***Collaborative State Technical Assistance Program Developed.*** NREL together with DOE HQ and the Denver Regional Office spearheaded the development of a new initiative where NREL, ORNL, and LBNL would partner with the regional offices in providing technical assistance to states. This initiative will focus on delivery of assistance on renewable energy portfolio standards to states, system benefit funds, use of renewable energy on state lands, and use of EERE technologies and measures to meet state and local environmental goals. NREL worked with the regional offices, other labs, and OWIP to develop this concept and will work with these partners to coordinate the delivery of technical assistance by the labs to the states.
- ***Innovative Fuel Cell R&D Concepts Developed.*** The Lab submitted to DOE 21 creative technical ideas in NREL's FY2004 fuel cell AOP. Ideas include innovative concepts from four different NREL Science and Technology Centers including Transportation, Buildings, Electricity/ Hydrogen, and Basic Sciences.
- ***Thermal Energy Storage Needs and Opportunities Identified.*** The Lab defined R&D directions and worked with DOE-HQ to define a logical pathway to develop the basis for a DOE Thermal Energy Storage Program. NREL worked via subcontractors to implement a focus group meeting in Washington to obtain the research/innovation perspective on TES needs and opportunities. Independent assessments of opportunities for TES within the food and cold storage industries were performed via an independent consultant. The results are being combined with those from the previously held industry workshop to provide both the short-term and the long-term perspectives of how TES can best be integrated into renewable energy and distributed generation technologies.
- ***New Initiative to Establish Clean Energy Centers in Africa Developed.*** In partnership with DOE, EPA, UNEP, the GEF, and PNNL, the Lab began developing a new initiative to establish Clean Energy Centers in Africa that can help build regional capacity to accelerate use of EERE technologies.

Key Forums Leadership and Influence

- ***Summit Leads to Blueprint for Domestic Hydrogen Codes and Standards.*** NREL helped to organize Fuel Summit VII in College Park, Maryland, May 28-29. One of the outcomes of the Summit was preparation of a national template for codes and standards for stationary hydrogen generators (reformers and electrolyzers) and stationary and portable fuel cells. This template compliments one previously developed under DOE/NREL leadership for hydrogen vehicles and fueling. The two templates provide a blueprint for coordinated development of domestic hydrogen codes and standards.
- ***Science Case for Large-scale Simulation.*** NREL was on the organizing committee for the DOE Office of Science workshop on the Science Case for Large-scale Simulation. The June workshop was a major activity in an on-going process of demonstrating the need for new ultrascale computing facilities for Office of Science missions. As part of the workshop, NREL staff organized a breakout session on software wngineering and management, and contributed to the summary Workshop report. This report was designed to assist in the FY05 budget process for the Office of Science. It also identified specific areas in which additional (smaller and more focused) workshops may be scheduled throughout the year, with the purpose of further demonstrating the opportunities of

large-scale simulation for scientific breakthrough in certain areas.

- ***Wind, HydroPower, Hydrogen Meeting.*** NREL worked with DOE to arrange a joint wind, hydropower, and hydrogen meeting with industry members and key stakeholders on the subject of the production of hydrogen by electrolysis using wind and hydropower. The meeting helped demonstrate DOE's commitment to the production of hydrogen from renewable energy sources and allowed the sharing of plans and analysis results between the industry, DOE programs, and the National Laboratories. This meeting is the prototype for another planned series of meetings with other renewable energy industry members to obtain input on the path forward for hydrogen production from environmentally clean energy sources. One immediate outcome of the meeting was that industry members felt that the exchange of information was so valuable that they would like to continue to dialog at six- month intervals.
- ***NREL Technical Leadership in IEA.*** NREL provided several leadership positions for the United States under the International Energy Agency's Agreement on the Production and Utilization of Hydrogen, including Annex 14, Photoelectrolytic Production of Hydrogen (Dr. John Turner is the U.S. representative), Annex 15, Photobiological Production of Hydrogen (Dr. Michael Seibert is the U.S. representative and is also a participant of the European COST 841 Biohydrogen program), Annex 16, Hydrogen from Carbon Containing Materials (Dr. Bob Evans is the U.S. representative to Subtask B, Hydrogen from Biomass), and Annex 17, Solid and Liquid State Hydrogen Storage Materials (Dr. Michael Heben is the U.S. lead for Carbon Materials).

  In the Biomass area, NREL provides leadership in six IEA Bioenergy tasks including Task 33 – Thermal Gasification of Biomass (Dr. Rick Bain); Task 34 – Ryrolysis of Biomass (Dr. Stefan Czernik); Task 35 – Techno-economic Assessments for Bioenergy Applications (Dr. Ralph Overend and Devin Craig); Task 38 – Greenhouse Gas Balances of Biomass and Bioenergy Systems (Matt Ringer: National Leader); and Task 39 – Liquid Biofuels (Mark Finkelstein: Operating Agent).
- ***Analysis Forum Explores Strategic Interests in Global Use of Renewables***. The Lab planned and led the 3rd Energy Analysis Forum that focused on understanding the U.S. strategic interests in the global use of renewables. The forum attracted more than 100 attendees. It focused on what is known, and what should be analyzed, in terms of the market opportunities, environmental and security implications, and economic development implications of expanding the use of renewables around the world. A consequence will be the formation of an International Analysis working group to identify and pursue further analysis of this topic.
- ***Biohydrogen Workshop Hosted.*** NREL organized and co-chaired with the Air Force Office Scientific Research, the Workshop on Biohydrogen, Molecular Biomimetic Systems, and Artificial Photosynthesis for H_2 Production in April.

PO 2.2 Demonstrate leadership in building strategic partnerships that leverage resources and advance DOE priorities.

PI 2.2.1 WFO projects are established, conducted, or expanded; providing opportunities to advance EERE technologies.

PI 2.2.2 Long-term strategic partnerships/relationships are established that create new opportunities for NREL and DOE.

Assessment Summary

The Laboratory demonstrated effective leadership through development of strategic partnerships that advance National Energy Policy priorities and DOE mission objectives, by sharing knowledge, integrating capabilities, and leveraging resources. In several cases, DOE and other organizations called upon NREL to serve as an objective, strategic advisor and partner. For example, NREL was asked by USDA and DOE to coordinate the technical review of proposals submitted for grants under the Farm Bill. In this and other similar activities, special effort was made to inform and educate NREL reviewers of their responsibilities as an FFRDC, responsibilities that transcend their traditional R&D role. NREL collaborations with other parts of DOE (particularly, NNSA and Office of Science) have enhanced the Laboratory's technical reputation and provided leverage for accomplishing the EERE mission. Leadership in establishing technology partnership agreements enables accomplishment of

mission objectives by leveraging DOE resources and providing a key mechanism for transferring NREL-knowledge.

Establishing Strategic Partnerships Leadership

- ***Expansion of Team Leverages Resources and Emphasizes Safety.*** NREL expanded the biomass-to-hydrogen team to include the University of Georgia-Athens. This move leverages a $2M state investment in biomass processing facilities and facilitates an enhanced emphasis on safety engineering.
- ***Strategic Partners Recruited for Proposed Virtual Carbon Storage Center.*** NREL formed a strategic partnership with Nobel Prize winner Richard Smalley from Rice University and senior scientists from Air Products and Chemicals, Inc., to lead a proposed virtual carbon-based hydrogen storage center. Sixty white-paper submissions were reviewed to select other participants in the proposed Virtual Center.
- ***Relationship with Joint Genome Institute Developed.*** DOE's Joint Genome Institute accepted NREL's proposal to finalize DNA sequencing of genes involved in hydrogen production. With understanding of active genes, NREL will transfer the oxygen-tolerant hydrogenase into other organisms for hydrogen production from a variety of feedstocks.
- ***NREL-Coordinated Review of Farm Bill Proposals.*** NREL collaborated with USDA and DOE in the technical review of Farm Bill Proposals. NREL coordinated the technical review of proposals submitted for EE/RE grants under Title 9006 of the Farm Bill. A total of 110 proposals were received and subsequently assigned to 1 or more of nine technical reviewers at NREL, ORNL, Sandia, and the U.S. EPA. In spite of numerous challenges, NREL successfully oversaw the timely completion of all reviews. In addition, NREL simultaneously provided detailed feedback to USDA, at their request, on options for improving the process in future years.
- ***Memorandum of Understanding (MOU) Signed with Arizona Public Service.*** An MOU was signed with Arizona Public Service (APS) for cooperation in the development of parabolic trough systems and components. The scope of the current cooperative effort is on Organic Rankine Cycle (ORC) development, concentrator testing, water cooling strategies, and thermal storage R&D.
- ***NREL Involvement in NNSA Program Continues to Yield Significant Outcomes.*** In its continuing role in the International Proliferation Prevention Program (IPP), NREL built collaborations with former Soviet scientists and U.S. commercial firms to advance technology toward commercial application. One of the projects has generated intellectual property jointly owned between two NIS institutes and NREL. It deals with the deposition of diamond like films on solar cell encapsulants, to minimize the uv-degradation of the encapsulant; patent application is in preparation. One of the active projects, for development of equipment for the accelerated testing of materials and paints, exposed to the solar ultraviolet (UV) radiation, is already bringing in royalties. This equipment accelerates testing of materials exposed to the solar UV-radiation (e.g., auto body paints), by a hundred-fold, thus significantly reducing costs in solar exposure tests. Another project on nanofibers was awarded an R&D 100 Award in May 2003. Among other applications, the alumina nanofibers can be used as ultra filters, to remove 99.9999% of viruses from water.
- ***Initial Portfolio of Activities Completed under NREL-UNEP Collaborating Center.*** NREL in partnership with UNEP, DOE, AID, and EPA developed a plan for application of resource assessment results to support policy and project decisions in key countries; prepared a draft proposal to the Global Environmental Fund for African Clean Energy Centers; enhanced methods of renewable energy by developing countries to better account for its value in mitigating price and other risks associated with reliance on fossil fuels; and conducted joint integrated environmental strategies workshops.
- ***Leading Role in Development of Global Village Energy Partnership Action Plans.*** NREL teamed with AID, DOE, UNDP, and the World Bank to provide technical assistance to Bolivia, Brazil, Colombia, other Latin American countries, and to Ghana to develop high quality action plans that identify opportunities and specific strategies for use of renewable energy to meet rural energy needs. This work is providing a model for other countries.
- ***Significant Office of Science Nanoscience Award Made to NREL.*** NREL scientists collaborated with colleagues from the University of Tennessee, Oak Ridge National Laboratory, and Lawrence Berkeley National Laboratory to develop an innovative nanoscience proposal entitled "Predicting the Electronic Properties of 3D Million Atom Semiconductor Nanostructure Architecture". The NREL-led effort was selected for funding by DOE/SC through a highly competitive process.NREL will receive $650K per year that will enhance the Laboratory's modeling capabilities in electronic

structures and model nanosystems with much larger numbers of atoms that is presently possible.

Establishing Technology Partnership Agreements Leadership

Work for others projects and other types of partnership agreements are of increasing importance to NREL because they offer multiple benefits in advancing NREL's mission. Among these are giving NREL greater insights into commercial requirements, transferring NREL-developed knowledge and know-how to others, and providing resources to sustain critical capabilities. Examples of WFO projects developed or active in the latter part of the year include:

- ***Alstom Tramway Simulation Control Strategies Completed.*** In a project with Alstom based on ADVISOR™ work, NREL developed a new control strategy and prepared it for optimization. Also, Alstom's existing control strategies were generalized and set up for optimization. This work provides experience and additional insight for heavy-duty modeling and target setting.
- ***Five-Year CRADA with AVL.*** Building on the successful licensing of ADVISOR™ from NREL by AVL, the two organizations have agreed on the technical content for a five-year CRADA including ADVISOR™ technology transfer, fuel cell technology simulation and analysis, and improving the emissions prediction capability of ADVISOR™. The CRADA is anticipated to be valued at more than $7M.
- ***Cooperative Research Relationship with CEC Leverages DOE Program.*** NREL established a cooperative research relationship with CEC to support mutual objectives in distribution and interconnection research. A work for others (WFO) is in process to formalize and execute efforts in FY04.
- ***Over $2M in Leverage for DOE International Program Received.*** NREL expanded its partnerships with USAID, EPA, State Department, UNEP, the Global Environmental Facility, and other organizations. These partnerships provide funding to leverage those available through the DOE International Program. This allows NREL and DOE to expand the scope and impact of it global market development programs.
- ***Technology Partnerships Provide Leverage to Accomplish FEMP Program Objectives.*** As a recognized leader in both project technical assistance and renewable energy technologies, NREL combines these strengths to leverage FEMP funds through additional support from agencies and other industry partners. As a customer-focused team, NREL developed relationships with EPA, NASA, GSA, BPA, JC Chang (Bureau of Prisons), Bechtel, BLM, Dept. of Commerce, National Guard, and US Forest Service to support their EERE needs, thus leveraging FEMP's strengths and capabilities at the Laboratory. These established partnerships have translated into more than $1M in leveraged dollars from non-DOE partners.

PO 2.3 Develop NREL's leadership competency.

PI 2.3.1 Leadership skills and abilities are developed and utilized.

PI 2.3.2 Succession plans for key Laboratory roles are developed and implemented.

Assessment Summary

NREL made systematic progress in developing a strategy that will support the Lab's short and long-term leadership development and succession planning needs. These efforts are directed at nurturing the next leaders and managers to support NREL's and EERE's mission. At the same time, the Lab continued to build its competency in areas of strategic importance through several key hires.

Performance Highlights

The Learning and Development Team, chartered in early FY03 to identify core leadership competencies in order to enhance NREL's development programs and succession planning process, made exceptional progress during this reporting period. The team evaluated NREL's vulnerabilities in critical positions by analyzing retirement data within one, five, 10, and 15-year time horizons. These efforts are important in understanding current and future talent needs, and developing training programs and succession efforts to address those needs. Using the recommended leadership competencies, a proposed career development tool was developed that can be easily integrated into NREL's existing performance review and appraisal process. Additionally, a talent management strategy was identified for consideration

by management that provides a more systematic, and on-going framework to support succession planning efforts, adjusted to the Laboratory's current and future strategies and critical roles needed to fulfill those strategies. The strategy provides an integrated approach that links all of NREL's human capital management activities together.

In addition to developing talent internally, NREL recruits expertise from outside the Lab that will further strengthen the Lab and contribute to long-term viability. Such hires made during this reporting period include:

- ***Experienced Licensing Executive Hired.*** Dr. Walter G. Copan, PhD. joined NREL's team that negotiates NREL intellectual property with its industrial partners. He joins NREL from Lubrizol Corp., where he most recently served as managing director of technology transfer and licensing. Dr. Copan is widely known and respected within the industry. He is a member of the Licensing Executive Society (LES), Technology Transfer Society, Association of University Technology Managers, National Business Incubation Association, Council for Chemical Research, American Chemical Society, Society of Automotive Engineers, and Directors of Industrial Research. He earned his Ph.D. in physical chemistry at Case Western Reserve University, Ontario, Canada.
- ***Charles Visser Hired to Lead NREL's Integrated Planning Efforts***. Mr. Visser is responsible for designing and implementing strategic and annual planning processes that will focus the Laboratory on its long-term vision as well as intermediate and short term performance. Mr. Visser was formerly director of global alliances for Space Imaging Inc., a technology start-up that pioneered the commercial market for high-resolution satellite imagery. Before joining Space Imaging in 2000, Mr. Visser spent more than 20 years with Amoco Corporation in a variety of management roles. He led petroleum exploration programs, international new venture development, corporate growth initiatives in emerging markets, alternative fuels strategy development, and corporate strategy. He earned his bachelor of arts in earth science from Dartmouth College, and his master of arts in geology from Harvard University, and an MBA from the Kellogg School, Northwestern University.

CO 3.0 Technical and Scientific Viability - MRI will ensure the long-term viability of the Laboratory by building and enhancing NREL's technical capabilities.

NREL Proposed Grade: Outstanding

PO 3.1 Build, enhance, and sustain NREL's scientific, engineering, and analytic capabilities.

PI 3.1.1 NREL technical capabilities are enhanced to effectively provide for long-term program needs and the Laboratory's sustainability and environmental goals (e.g., staff, facilities, and equipment that enable science and technology work at NREL):

- Staff expertise – strategic hires, DDRD projects, key staff additions and staff development assignments, training, and experiences
- Facility capabilities – enhancements to existing facilities and/or completed milestones in constructing/operating new facilities that represent added capability
- Equipment – enhancement and/or addition of scientific equipment; new concepts/areas of expertise – DDRD investments and outcomes.

Assessment Summary

NREL continues to enhance its technical capabilities in support of strategic program and national needs through focused investments in staff, equipment, facilities and ideas. Through internal investments in exploratory research, NREL continues to substantially extend the scientific and technical capabilities necessary to support long-term program needs, national energy goals, and national environmental sustainability goals. As a result of program support and strategically selected investments, NREL strengthened its long-term capabilities in computational sciences by acquiring a chemistry package that will help advance several different research areas at the Lab. Analytical equipment was expanded or purchased to provide new tools that enable state-of-the-art measurements and resulting data.

Among the instruments purchased for the new Biomass Surface Characterization Laboratory was a scanning electron microscope, which will be used for composition analysis, topographic imaging, and structural microcharacterization.

NREL's vision for the future of its physical sites was demonstrated by the completion of the 25-year NREL General Development Vision, which provides the framework for developing the South Table Mountain Site and National Wind Technology Center. This plan will be instrumental in guiding the Lab's strategic investments in future buildings and infrastructure. NREL's next major research building, the S&TF (discussed under Critical Outcome 4.0) will provide a unique capability to develop advanced technologies for thin-film and nanostructure fabrication in support of renewable energy and energy efficiency goals. NREL also developed plans for key additions of critically needed new facilities at the National Wind Technology Center.

Biomass Capabilities

Development of Biomass Surface Characterization Laboratory Initiated. The NREL and DOE Biomass Program have committed to establishing a very unique facility at NREL for the advanced characterization of biomass surfaces (materials). NREL used $2.2M in capital funds provided by OBP to purchase microscopy equipment to build a world-class Biomass Surface Characterization Laboratory. These new surface characterization tools greatly enhance NREL's resources for developing improved biomass pretreatment technology and improved enzymes for cellulose and hemicellulose hydrolysis. Among equipment purchased for the new laboratory were:

- Scanning electron microscope for compositional analysis of samples, topographical imaging, and structural microcharacterization.
- Transmission electron microscope for high-resolution imaging, and structural, compositional, and cross-sectional analysis.
- Near-field optical microscope for fundamental material and nanoscale studies.

The Biomass Surface Characterization Laboratory will keep NREL at the cutting edge of botany, biochemistry, chemistry, and material and computer sciences. It will also help DOE achieve the long-term goal of developing biorefineries to produce fuels, chemicals, and biobased products from lignocellulosic biomass that are cost competitive with petroleum-derived.

Computational Sciences Capabilities

Computation Chemistry Package Available for use at NREL. NWChem has been installed and made available to NREL scientists on the NREL IBM high-performance computing system. NWChem is a computational chemistry package. It is designed to run on parallel supercomputers and to treat large problems efficiently. In addition, the companion software package, Extensible Computational Chemistry Environment (Ecce) has also been installed. It provides a sophisticated graphical user interface, scientific visualization tools, and the underlying data management framework enabling scientists to efficiently set up calculations and store, retrieve, and analyze the rapidly growing volumes of data produced by computational chemistry studies. These software packages add to the capabilities of NREL.

Visualization Capabilities Enhanced Based on Workshop Results. NREL held its first workshop on Computational Science in Biology, Chemistry & Materials Science on April 3rd. The workshop focused on common needs and challenges in numerical modeling and simulation for scientists - the most pressing of which was a requirement for scientists to be able to visualize the results of their scientific simulations. In response to this expressed need, NREL specified and purchased a stereoscopi, 3-D visualization system. This system, which is currently being installed and tested, will greatly enhance NREL's scientific modeling and will aid scientists in accelerating their research and in understanding basic phenomenal processes.

Strategic Hire Augments Computer Programming Capabilities. The hire of Mr. Peter Ellis was made to augment our capability in computational sciences for building energy simulations. Ellis comes to NREL with experience as a mechanical engineer and in computations. The retirement of a research fellow working in this area and a transition to an emphasis on EnergyPlus were the drivers for this hire and will keep NREL in a leadership role in building energy simulation and in communicating the scientific results.

Distributed Energy and Electric Reliability Capabilities

Test Facility gets new Inverter Test Bed. NREL completed construction of an inverter test bed at the Distributed Energy Resource Test Facility (DERTF). This test bed contains 13 inverters and will be used to test the response of multiple distributed resources to abnormal utility conditions. This work will provide valuable insight into the impacts of large numbers of distributed resources on single distribution feeders and will add to the capability to test multiple inverters at the DERTF.

New test bed at the Distributed Energy Resource Test Facility contains thirteen inverters and will be used to test the response of distributed resources to abnormal utility conditions.

Advanced Thermal Conversion Lab Receives Upgrades. NREL commissioned the second test station at the Advanced Thermal Conversion Lab for high-speed testing of full-scale waste heat recovery, HVAC (heating, ventilation, and air-conditioning), and air-cleaning technologies, and has already used the test station to complete the evaluation of 16 new heat recovery and dehumidification devices. Among the upgrades made to the lab is the addition of automated contaminant samplers originally developed under NREL's DDRD Program (Director's Discretionary Research and Development), which are being applied to the development of next-generation air cleaners. Additional upgrades to the lab provide the ability to precisely, quickly, and accurately evaluate new full-scale VOC (volatile organic compound) filters. These upgrades enable researchers to develop improved thermally activated technology (TAT) components, facilitate the integration of components into energy efficient systems to ensure effective indoor environmental quality, and provide DOE with in-depth understanding of the state-of-the-art of TAT HVAC and waste-heat recovery technologies.

FreedomCAR and Vehicle Transportation Capabilities

Toxic Measurements Capability Added. NREL added the capability to measure toxic emissions at its ReFUEL laboratory, which will increase researchers' understanding of the impacts and compliance of advanced engines and fuels for high fuel-efficiency transportation. A gas chromatograph (GC) will enable researchers to speciate and quantify emissions of C1-C12 hydrocarbons — including 1,3-butadiene and benzene. Both of these chemicals are carcinogens and are being considered by the California Air Resource Board for future regulation. A high-performance liquid chromatograph (HPLC) will quantify emissions of aldehydes and ketones, which are pulmonary irritants.

A new liquid chromatograph in NREL's ReFUEL laboratory allows researchers to analyze aldehyde emissions.

Energy Storage Lab Gains New Capabilities. The energy storage team added new experimental capabilities to its laboratory. The team:

- Acquired a unique, custom-made AC power amplifier for testing battery pre-heating concepts for vehicles that operate in cold climates and evaluating the effects of high-frequency harmonics on battery life.
- Designed and installed anode testing equipment for quickly screening the effectiveness of anodes with different materials and designs.
- Designed and fabricated a device to measure the thermal conductivity of battery materials, an important parameter for battery thermal analysis.
- Designed a new battery calorimeter for measuring heat generation from batteries, information essential for proper thermal management of batteries.

Laboratory Flexibility and Capability Upgrades for Future Generations of Engines and Vehicles. The ReFUEL laboratory control and data acquisition systems were upgraded to modern, more flexible PC-based technology. These upgrades significantly improve the ability of the lab to be reconfigured to meet new test protocols in the demanding and rapidly evolving field of heavy-duty vehicle research. The lab was also refurbished to enable it to meet the 2007 emission measurement testing standards. The most significant of the changes was the installation of the Class 1000 clean room for particulate matter metrology, which features precise environmental controls for conditioning particulate matter filters prior to measurement.

New Class 1000 clean room for particulate matter metrology for ReFUEL lab.

Distributed Computing Capability Built into ADVISOR™. With the installation of the distributed computer program "Condor" on twenty personal computers, NREL's vehicle systems analysis team enhanced its analytical tools. This initial cluster includes both dedicated and staff-used workstations, including processors ranging from 500 MHz to 2.8 GHz. The system greatly increases the utilization of computational power by storing jobs that need to be run in a queue and then executing them on available machines. Plus, the DIRECT optimization routine that was used extensively with ADVISOR™ was modified to exploit the distributed computing resources. As an indication of the power of this new analytical computing capability, it was tested on a fuel-cell vehicle design problem using ADVISOR™. In this analytical test, more than 1,000 hours of computational time were completed in 72 hours of clock time.

Hydrogen, Fuel Cells, and Infrastructure Technologies Capabilities

New XRD Facility. NREL established a new X-ray diffraction (XRD) facility that will improve capabilities. The new facility will allow mapping of large samples, screening of combinatorial samples, and in situ thermal processing of samples.

New Capabilities for Synthesizing Carbon Nanotubes. NREL has developed two new capabilities for synthesizing single-wall carbon nanotubes (SWNTs). The first is the addition of a heated arc-discharge synthesis reactor. The second, a capability derived from a DDRD project, is the development of a hot-wire chemical vapor deposition system for SWNTs. Besides

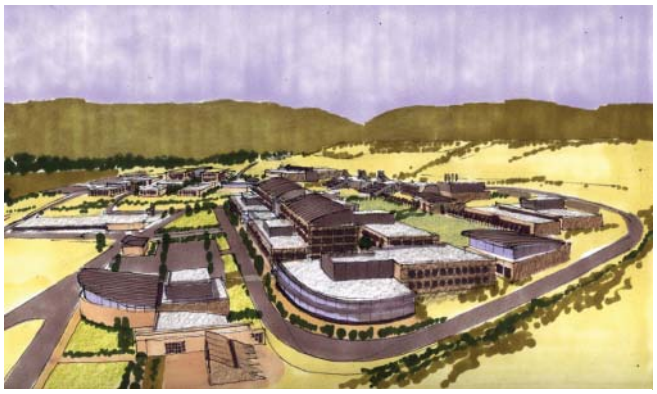
being very promising for hydrogen storage, SWNTs also have potential applications for gas separations, fuel-cell membranes, batteries, photovoltaics, composite materials, nanoscale wires, and more. The promise of these approaches for making SWNTs is that they are continuous production techniques, which has great advantages over NREL's currently available laser-based batch processes.

NREL General Development Vision (Site Planning and Development)

NREL Delivers Completed Site Development Vision to DOE and Management. NREL completed the 25-year General Development Vision for both the South Table Mountain campus and the NWTC campus. The development of the plan involved discussions with more than 150 of NREL's managers, and staff members. The planning process also included site planning consultants, members of NREL's Advisory Board, architects and engineers, meetings, workshops, and reviews. This plan will provide the framework for developing NREL's sites over the next 25 years. The plan was documented in draft reports that were orally presented to:

- The NREL design advisory board in May
- NREL executive management in June
- MRI board of governors in July

A revised draft report that incorporated comments from previous reviews was presented to GO and NREL executive management in August 2003. A final report incorporating the latest review comments is now being prepared and will be ready by the end of October 2003.



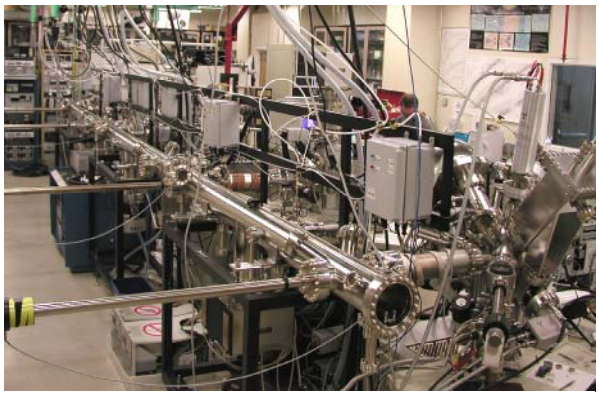
Artist rendition of completed South Table Mesa campus as seen from the east entrance.

Quality Assurance

Attaining ISO Accreditation. NREL made significant contributions to building the Laboratory's technical capabilities and long-term viability by obtaining/retaining ISO 17025 accreditation. ISO 17025 accreditation is important to NREL because it is the internationally recognized standard for testing and calibration laboratories. Having this accreditation acknowledges that the Laboratory has a quality system in place that enables it to deliver testing and calibration results of known quality. NREL developed needed documentation and training, and performed quality audits that enable the NWTC Certification Team to maintain its ISO 17025 accreditation, and to gain accreditation for the NCPV Solar Cell/Module Group's testing and calibration.

Solar and Solid-State Materials Research

Surface Analysis Process Integration Tool Developed and Installed. For the surface analysis lab in the Solar Energy Research Facility (SERF), NREL designed and installed a system that integrates Auger and XPS analysis systems with a surface modification and deposition workstation, and a glove box. This new tool enables a semiconductor surface of a device to be deposited, analyzed for elemental and chemical composition, and then modified all in one, interconnected, clustered system. The heart of the design is a vacuum transport system that conveys the semiconductor device from station to station without exposure to ambient atmosphere. The development of this tool serves as a prototype for more elaborate capabilities planned for the new S&TF.



New NREL custom designed cluster tool in the surface analysis lab combines Auger and XPS characterization capability with deposition

Single-crystal X-ray Diffraction Facility. Under a DDRD project, NREL established the capability to perform X-ray diffraction measurements and analyses on single crystals. This provides NREL with a fundamental analytical capability to ascertain the crystalline structure of new materials, which is especially important for photovoltaic and solid-state technologies.

New Diagnostic Capability for Characterizing Nanostructure Matter. Under a DDRD project, NREL is establishing a new capability to characterize the energy levels of individual nanoparticles and the dynamics of interparticle charge transport among assemblies of these nanoparticles. This new capability arises from a unique approach of combining interrelated diagnostic techniques – low-temperature and ambient tunneling spectroscopy, photocurrent transient spectroscopy, and electrochemical transistor setup. This new capability will yield insight into the interplay between the energy structure of single particles and the charge transport among particles. As part of this project, a new low-temperature AFM/STM instrument was purchased and installed.

Wind Energy Capabilities

Planning for Large Wind Turbine Test Facility. NREL Site Operations and the NWTC have continued to move plans forward for building the Large Wind Turbine Test Facility. This is a facility that would house an 8-MW dynamometer and a 70-meter blade-testing area to accommodate the testing of the latest generation of MW-scale wind turbine components being developed by the wind industry. The efforts thus far this year have included the development of Critical Design 0 and OMB 300 submittal packages, budget and schedule estimates for DOE management review, and briefings to explain the requirements and need for such a facility. NREL has involved key industry members in a dialog to ensure the facility meets the requirements of the industry.

CO 4.0 Mission Support - MRI will manage and enhance NREL business and management systems, work processes, and capabilities to provide an effective and efficient work environment that enables the execution of NREL's mission.

NREL Proposed Grade: Outstanding

PO 4.1 Deliver efficient, effective, and responsive business and operational support.

- PI 4.1.1 Performance of Lab-level processes, functions and businesses management (e.g., Lab fiscal management, staff turnover rates, space utilization rates, etc.).
- PI 4.1.2 Performance on functional-level key task priorities and process metrics as documented in AOPs and NREL/GO performance agreements for the following functions: financial systems and management, site and facilities management, procurement and subcontracting, information services, human resource management, legal support, quality management, and performance assessment.
- PI 4.1.3 Demonstration of effective management of facility enhancement and construction projects and enhancement and/or additions of enabling equipment.
- PI 4.1.4 Progress against the goals and objectives stated in the GO/NREL "Performance Agreement for Energy Management."

Assessment Summary

NREL continued its strong track record of delivering exceptional mission support that furthers EERE and DOE goals. Effective financial and business management mitigated negative impacts due to the late receipt of funding as well as pension fund pressures, thus allowing the Lab to maintain a stable labor multiplier. Careful pre-planning resulted in timely subcontract awards demonstrating the Lab's agility in initiating research efforts. These results were achieved through collaboration across the Lab, in partnership with GO.

Institutional emphasis on a holistic approach to the management of human capital has resulted in enhanced benefits without increased cost, improved performance management processes, and greater flexibility in how staff accomplish their work. These efforts are directed toward providing a work environment that promotes attracting and retaining the best and brightest to support NREL's mission cost effectively.

NREL stewardship of critical infrastructure continues to assure the appropriate use and protection of DOE assets and investments. Effective and efficient design and construction project management, coupled with stakeholder outreach and close coordination with GO, has resulted in reaching CD-2 approval on the S&TF, a new facility that is critical to NREL's mission. At the same time, existing lab and office space is being managed to optimize current S&T needs against the Lab's current space constraints. NREL has maintained reliable IT infrastructure availability, increasing service hours while effectively managing the ever increasing cyber security threats. NREL's management of site security is becoming increasingly transparent; efficiently dealing with changing environmental conditions.

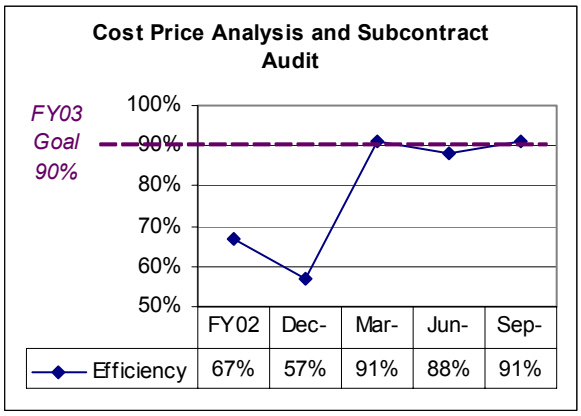
Performance Highlights

Business Management

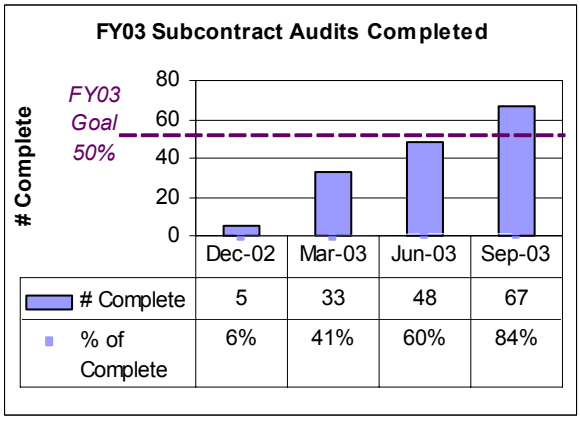
Strong collaborative efforts across NREL in partnership with DOE-GO resulted in closeout of all FY98 Limited Term Appropriations (Fund Type Y-8). Planning for this effort began two years ago and ensures the effective use of funding as well as timely closeout thereby avoiding a situation in which planned program work cannot be completed due to lack of funds.

NREL completed the planning and testing of systems required to support accelerated financial reporting to DOE, cutting two days off of month-end closing schedules. This represented a significant effort on the part of all mission support with more than 500 hours of programming time and 200 hours of testing and documentation for user groups. This effort supports DOE's need to provide timely financial statements to OMB and Congress.

Full implementation of two Make/Buy recommendations from FY02 helped streamline processes. Efficiency of total work hours increased dramatically after outsourcing the Subcontract Audit function in December. These results and the use of expanded cost/price analysis were important to the Limited Term Appropriations closeout project and FY03 procurement action negotiations and awards.



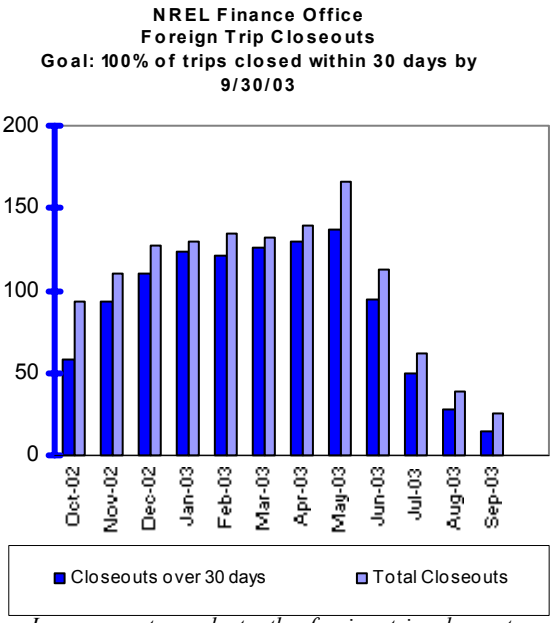
Efficiency averaged 90% from January to September 2003



NREL's goal to complete closeouts for at least 50% of beginning fiscal year requests has been exceeded.

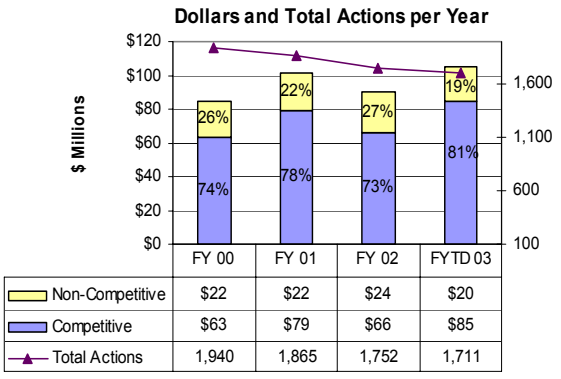
Similar gains were realized with the new approach to document scanning that allows efficient web-based document retrieval, more cost-effectively, with information now available weekly. Two new Make/Buy studies were conducted in FY03 in the areas of Conferences and Public Web Infrastructure. Results of these studies will begin to be realized in FY04. Indications to date are that, regardless of the decision of whether to make or buy, the process is improved.

In early FY03 NREL recognized certain inadequacies in the closeout of foreign travel vouchers and took steps to improve the process that enabled timely receipt of Subcontract Foreign Travel Reports.



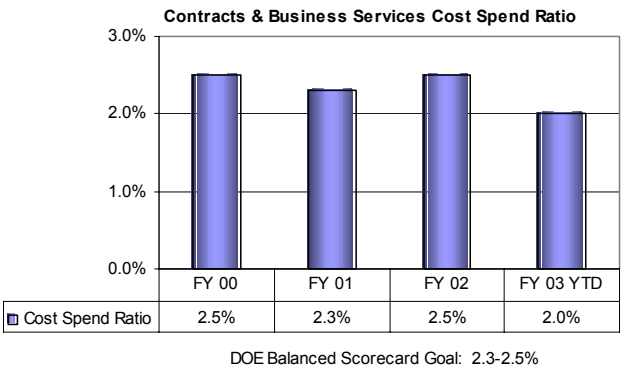
Improvements made to the foreign trip closeout process have resulted in a reduction to the number of trip closeouts outstanding past 30 days.

NREL continued to meet or exceed the majority of its Balanced Scorecard subcontracting performance goals. Preplanning efforts played an important role in mitigating the impacts of delayed funding; ensuring that subcontracts were ready to place as soon as full funding was received. NREL's FY03 subcontract plan of $108M was exceeded by 10% ($119).



The total dollar value of awards is up over FY02 while the number of actions is slightly lower; the competition goal (70% competitive) has been exceeded.

The cost-to-spend ratio of 2.0% for procurements is below the target range of 2.3-2.5%. The target of 2.3-2.5% is considered the range of maximum efficiency, ratios below this are indicative of increased workload with no increase in resources. This level of effort is laudatory however, such performance over time is very difficult to sustain.



Subcontract dollars awarded increased in FY03 while the number of FTEs supporting awards decreased over FY02 levels.

The closeout of 557 subcontracts was noteworthy, even though somewhat less then the goal to closeout 600, given the unanticipated demands resulting from the efforts to close Limited Term appropriations and the time required to meet with and provide information to the IG's audit of all laboratories subcontracting efforts.

As a result of the findings and recommendations that came out of NREL's management-directed assessment of the Technology Partnership Agreement process, the Lab is strengthening its internal controls and making numerous process improvements. As illustration, agreements are monitored weekly to promote early problem identification and resolution. A pilot with the National Bioenergy Center was initiated to conduct joint biweekly reviews among NREL stakeholders to identify issues or obstacles in initiating new agreements. The NBC was chosen as a pilot because of the growth expected in new Agreements. NREL and GO collaboration and interaction has also been strengthened.

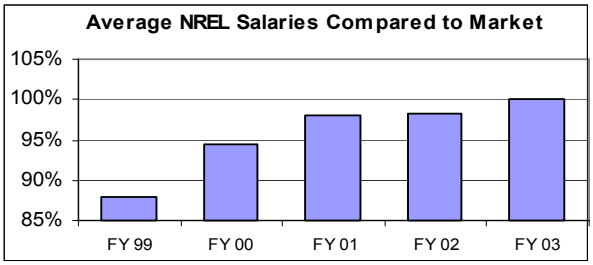
Changes made to the P-Card program, reported at mid-year, are promoting enhanced compliance thereby reducing risk to NREL and DOE. Results from an Internal Audit conducted during this reporting period found the P-Card Program to be functioning as intended with no significant deficiencies identified. DOE recognized NREL's Program as noteworthy, and NREL was asked to be a key member of DOE's process improvement team.

Human Capital Management

The Lab continued to strengthen the integration of salary planning with the overall appraisal process. Input from staff was solicited regarding the performance appraisal process, results were reviewed and summarized. In parallel, a compensation system study was conducted to evaluate NREL's existing job title structure and compensation system to support integrated systems. Changes to the process will be finalized in FY04. This effort will allow NREL to more quickly implement process improvements in FY04.

NREL completed an evaluation of personal time off options to develop a Personal Time Off (or Combined Leave) Program. The goals of this program are to provide staff greater flexibility in use of their time off options while maintaining a comprehensive and cost effective Benefits program. The final Program, which was approved by management and GO will be implemented in January of FY04. It is expected that significant productivity gains will be realized because of this change.

With the continued support of DOE and the management of salaries to market, NREL has met its goal of having average salaries at 100% of market. Competitive pay and benefits together with a meaningful performance management approach, is critical to attracting and retaining staff that will assure



Improving salaries helps to assure the Lab's viability.

the Lab's viability well into the future.

NREL's focus on its staff, along with the Lab's compelling mission, are key contributors to its ability to attract and retain world-class capabilities.

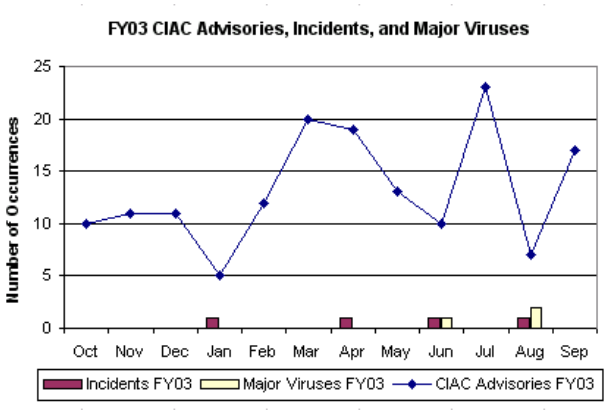
NREL monitors the number of hires, the cycle time for bringing on new hires and the average cost to placement to assure that once a position opens, it can be effectively and efficiently filled. FY03 results show a reduction in hires, which was expected due to the late receipt of funding. The average days-to- placement was slightly lower than previous results. The cost to hire was somewhat higher in FY03 compared to FY02 due to an increase in the number of new hires requiring relocation. However, the cost remains much lower then that seen in previous years.

	# of Hires	Average Days to Placement	Cost to Hire
FY00	181	59.6	$6,161
FY01	122	65.5	$8,720
FY02	124	57.1	$3,157
FY03	81	55.0	$4,092

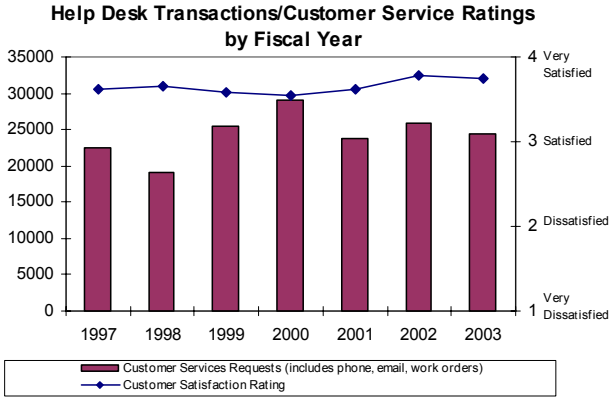
Equally important to attracting qualified staff is managing their performance once they are hired. This requires a balance between the time and attention given to outstanding performers and to staff that are struggling. Proactive, collaborative involvement of legal counsel with HR processes ensures there is a balance. As a result, the Laboratory has no litigation pending for the first time in at least 10 years. In addition, upfront and active engagement of counsel in other aspects of the Lab's business demonstrates consistent value as evidenced by no patent inquiries, no contract claims over the past five years, and favorable settlements.

Operational Infrastructure Management

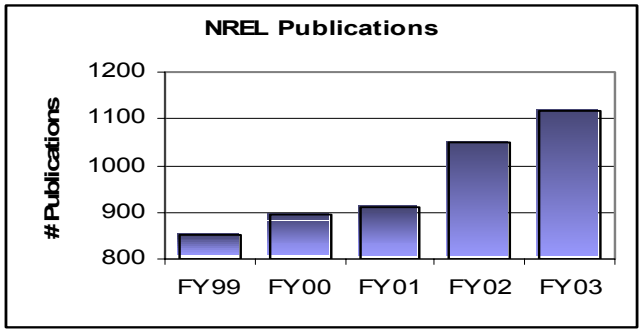
IT infrastructure was managed to ensure network service availability at or above NREL's target of 99.7%. Also, NREL investigated more than 158 CIAC advisories (up from 129 in FY02), had three localized virus infections, three cyber security incidents, and most importantly, zero downtime due to cyber incidents. NREL's virus protection strategy, along with good Laboratory practices demonstrated by many NREL employees, has helped to minimize the impact of major threats such as the Blaster and Sobig worms. At the same time, the Lab has quickly responded to increasing ad hoc cyber-related requests and DOE notices sent for review.



Client Services (which includes the help desk, technicians, training, and desktop integration) continue to respond to demand; in FY03 24,303 transactions were completed while maintaining a very high level of customer satisfaction.



NREL's Publication Database plays a key role in supporting the dissemination of important research and program information to the public. Since trending started in FY99, the total number of publications managed through the database has consistently increased.

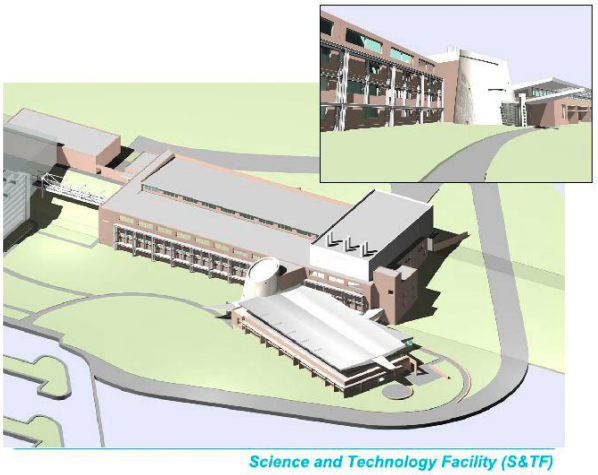


Equally important to disseminating research is providing the capability for NREL researchers to efficiently access research. Library Services effective management of desktop resources has facilitated an average of 65 literature searches and an average of 219 electronic journal uses for every S&T staff member. Metrics such as these help provide a basis for assessing progress in the future.

Site and Facilities Management

The Lab continued to provide exceptional stewardship and protection of DOE facility and equipment assets and investments.

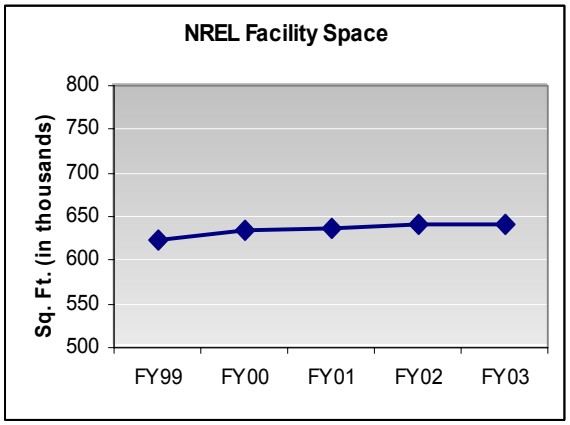
NREL, with strong support from GO, completed and has gained approval of the CD-2 for the S&TF. This is a critical milestone for the Lab that was accomplished on schedule and budget due to effective design and construction project management as well as strong collaboration across the Lab and with GO. NREL researchers completed comprehensive reviews of both the "100% Design Drawings" and the "Issue for Bid" drawings. An External Independent Review was conducted in July. The panel was charged with reviewing and validating the S&TF project Performance Baseline and to assess the overall status of the project management and control system. In addition to identifying issues requiring attention, the



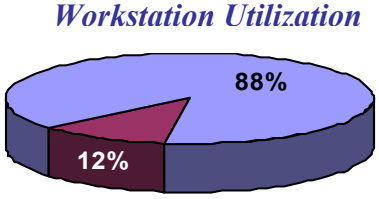
Artist rendition of the Science and Technology Facility (S&TF).

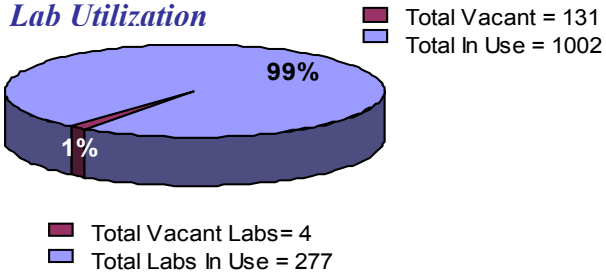
panel also noted three very positive and important findings, concluding that: a) the project scope supported the DOE mission; b) the functional requirements were clearly identified and thoroughly recorded in the User Input document; and c) the users were very involved and well-integrated into the design process. Based on the review comments, NREL met with DOE-GO and HQ as well as the Office of Science to develop a corrective action plan (CAP) strategy. The final CAP was presented and CD-2 approval was received in September. The approval of the S&TF CD-2 was a difficult challenge. The Office of Engineering and Construction Management (OECM) completed this effort within the context of a new and evolving critical decision (CD) process. It required a maximum application of critical Site Operations resources during the last quarter of FY03. The CD-2 approval was a result of the NREL/GO efforts above coupled with aggressive outreach to stakeholders regarding the importance of this facility to the NREL and EERE mission.

Making the S&TF a reality is especially important considering that a significant challenge exists for NREL in the management of space.



As can be seen in the graphs, increases in overall facility space have been minimal over the last five years with only 2.6% overall growth while payrolled employee headcount has increased 13% since FY00. Similarly, workstation and laboratory space is at a premium.

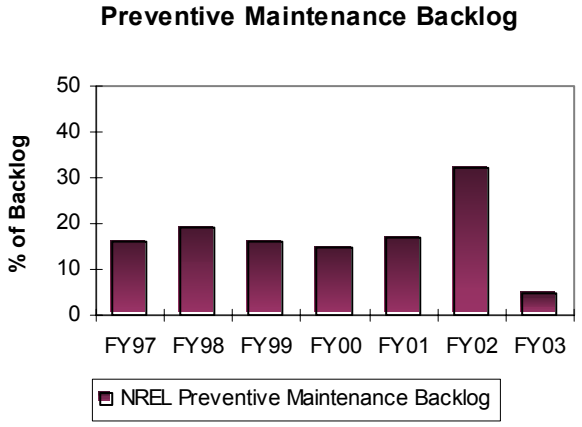




NREL proactively and consistently responds to this issue within existing constraints through facility modifications such as those completed this year in Building 16, as well as through exploring potential releasing options. Cost savings were realized due to aggressive renegotiation of leases, such as DW Buildings 16 and 17, and the Joyce Street facility.

Coupled with constructing new facilities and modifying existing ones to accomplish the mission, the Laboratory also maintains an on-going preventative maintenance program. In FY02 the preventative maintenance backlog was trending up, signaling a potential process issue. Management re-evaluated the process, making a number of changes designed to improve overall efficiency. In addition, an objective third-party subcontractor completed a comprehensive

facility condition assessment for all DOE-owned facilities. The quantitative results of the assessment validate the state of maintenance of the facilities is "good," with a Facilities Condition Index (FCI) of 2.2. The "good" FCI condition category ranges from 2.0 to 4.9. Prior year GPP and GPE funds were spent largely on non-infrastructure projects that expand capacity. Operating funds were directed predominantly at ongoing facility maintenance. The FCI assessment confirms that NREL's balanced approach supports facility and capacity needs, and results in the protection and maintenance of DOE assets.



Significant improvements have been realized in FY03 to improve overall efficiencies.

NREL continued to demonstrate stewardship through its day-to-day management of facility and site services. Janitorial and building maintenance costs continue to fall at or below established industry benchmarks; turnaround time for shipments received and delivered met established goals; and property management goals and objectives are on track.

Security Management

NREL manages security in a manner that is seamless to staff while protecting DOE assets and interests. Additional integration of security management processes was achieved, particularly in the development and implementation of processes related to the continually evolving Foreign National and Counterintelligence directives. Efforts were focused on making these new processes effective yet unobtrusive, and staff acceptance has been exceptional. Work has progressed on documentation of integrated security processes, and will continue into FY04.

Necessary and appropriate emergency exercises were completed for all facilities and functional areas. Exercises included Cherryvale Fire Department high angle training at the NWTC; evacuation exercises at all major facilities; and a high angle rescue exercise with Flight for Life participation. These exercises were considered very effective for all participants.

Operational efficiencies were improved across the Laboratory by combining Computer Security Awareness training with the existing Web-based Security Refresher training, and performance measurement was enhanced through the completion of Laboratory-wide physical key audit.

PO 4.2 Build and enhance NREL's business and operational support capabilities.

- PI 4.2.1 NREL infrastructure, work processes, systems, and tools are developed, implemented, and improved.
- PI 4.2.2 NREL support capabilities are strengthened through key staff additions, staff development assignments, training, and broadening experiences.
- PI 4.2.3 Outcomes of audits and external reviews are utilized to plan or implement improvement.

Assessment Summary

NREL's commitment to continuous improvement is becoming more visible and tangible internally and externally. Results, such as those presented under Performance Objective 4.1, provide clear evidence of these productivity gains. Underpinning this consistently strong level of performance lies a commitment to integrated planning, budgeting and assessment – NREL's performance-based management approach – that promotes alignment of staff to strategy, the establishment of challenging goals, systematic monitoring, and evaluation of progress towards those goals, and then rewarding exemplary performance. This approach to managing the Lab was cited as a best practice by both the NAPA review and more recently by DOE's Laboratory Operations Board.

The Lab continued to develop and implement new performance metrics to help better evaluate the effectiveness, efficiency and value of core infrastructure, work processes, and supporting tools. These metrics have also been designed to support better understanding of implementation across the Lab. The knowledge gained is then used as feedback for improvement.

NREL's commitment to a well-trained and motivated workforce is demonstrated by staff survey results and actions taken in response to those results as well as HR program enhancements. FY03 program enhancements were directed toward offering staff more flexibility in how they accomplish work, benefit enhancement, and promoting diversity in the workforce.

NREL continues to be a leader in "walking the talk" in energy efficiency and renewable energy. EERE concepts are incorporated into all facets of the Laboratory from design and construction, to facility maintenance, through individual staff behaviors.

Performance Highlights

Expanded use of Performance Metrics Support Performance Improvement

The Laboratory continued to build upon the progress made in previous reporting periods by expanding the use of performance metrics to new areas of the business and by enhancing existing metrics to communicate trends more effectively. The goal continues to be to get the right information to the right people to support effective decision-making. In addition to new metrics reported in PO 4.1, such as space utilization, metrics were developed in areas such as library services, records management, integrated business systems, voluntary separation, and hiring demographics. Monthly, quarterly, and yearly trends are now available for many metrics. More important however, are the results. As example, metrics were developed to track staff compliance to NREL publishing standards with results indicating potential inadequacies in implementation. These results were shared with management and actions were taken to improve compliance, which helps assure that NREL-developed publications receive appropriate reviews thereby protecting the reputation of the Laboratory.

NREL's FY02 Staff Survey: a Lab-Level Management Tool

The survey has become an important management tool for staff to provide input and feedback, and was noted by staff as one of the most positive changes that has occurred at NREL in the past three years. Analysis of the FY02 survey results was completed in FY03 and actions were developed to be implemented over the last half of FY03 and into FY04. The results served as input to developing the FY03/04 actions.

Several dominant themes were noted in "write in" responses that also helped shape actions. The desire that the Lab continue its focus on electronic processing was strongly expressed. Continued interest in telecommuting, alternative work schedules, and post-retirement benefits were equally strong. Staff also expressed a desire for management to assess NREL's recharge system for potential improvements. Continued process improvements were also noted as appreciated and desired. FY03/04 Lab-level actions and their status are:

Development: Results indicated that mentoring and career development by managers warranted further study. Additional data has been gathered providing insights into staff expectations and needs around career development, mentoring and specific ways of enhancing development in all career paths and levels. Trends and themes were identified, assisting in prioritization of program(s) to be delivered. These efforts are establishing a foundation for an integrated approach to learning, career development, succession planning, and assessing the critical skills needed in the future.

Recognition: Staff perceptions of NREL's awards and recognition programs produced the greatest decline in overall positive response (-13%). This is a surprising result given the breadth of NREL's recognition programs, and the historical importance of these programs to staff. Interviews and focus groups of staff and managers were conducted to identify and clarify staff concerns. Recommendations for addressing identified issues are being developed for potential implementation FY04.

Work Environment and Benefits: Responses again highlighted a desire for telecommuting and changes to alternative work schedules, as well as consistent criteria for approving requests in both areas. NREL instituted a pilot telecommuting program April 1 -

September 30, 2003 that will be evaluated in FY04 with results presented to executive management for determination if the program should be continued, modified, or retained as is.

Recharge System Assessment: Initial assessment scoping with executive management was completed and the assessment team, a representative cross section of the Lab, was identified. The assessment plan was drafted, including lines of inquiry. The assessment is targeted for completion in the first half of FY04 so that results and recommendations can be considered prior to initiating FY05 planning and budgeting activities.

Continuous Improvement in the Management of Human Capital

NREL continued to place emphasis on HR systems and benefits offerings designed to attract and retain the best and the brightest in support of EERE's mission. A Benefits Value Study was completed in late FY03. Results showed improvement in long-term disability and life insurance, which were benefits areas that NREL placed improvement efforts on in FY02. Recommendations for future areas of emphasis will be presented to management in FY04. An updated Post Retirement Medical proposal was developed for DOE-GO consideration and will be submitted in FY04. A Telecommuting Program was piloted that provides a framework to address the various issues related to such work arrangements including resources, infrastructure, safety, and security. A Diversity Assessment was conducted, additional activities occurred that enhanced the current program, and further enhancements will be made in FY04.

Improving Productivity through Automated Support Systems

NREL continued to drive improvements in its business processes through the Lab's Electronic Processing Initiative (EPI). The goal of the EPI is to increase effectiveness and efficiency of NREL business processes through reduction of non-value-added work and elimination of redundant process steps. Progress during this performance period was made in the following areas:

***Approval Authorities*:** NREL implemented a new policy for approval authorities clearly identifying hierarchies for different types of approvals and delegation of authorities. This is a pre-requisite to automation of electronic processes. The new policy was implemented in May.

Lab-Wide Communications*:* A Web site was created for on-going communications on the status of initiative, as well as the status of the individual projects. The Web site includes Frequently Asked Questions, as well as a mechanism to enable staff to submit questions on any aspect of the initiative. NREL staff were also kept informed via global e-mails and several articles in NREL Now.

Software Licensing: NREL worked with DOE and Oracle during the negotiation process of the DOE/Oracle licensing agreement signed in June. NREL is currently negotiating Oracle licenses for the Laboratory based on the DOE contract allowing significant (21% greater than GSA pricing) discounts to NREL.

Projects: Project teams are at various stages as indicated in the chart below. In order to document business system requirements, project teams must first document each current process, brainstorm and document improved future processes and then identify and validate the business system requirements. These project deliverables were validated using Lab-wide focus groups.

FY03-04 Projects		
Project	***Scope***	***Status***
Purchase Card Transactions	Automate the recording, approval, and routing of purchase card transactions	Business system requirements and software solution being validated.
Electronic Purchase Requisitions	Automate the creation, approval, and routing of purchase requisitions	Business system requirements completed. System design, configuration, and setup started.
Property Transactions	Automate the recording, approval, and routing of property accountability, transfers, and passes	Business system requirements completed. Technical design started.
Travel Expense Reporting	Automate the creation, approval, and routing of travel expense reports	Business system requirements in progress.
Timesheets and Labor Costing	Automate the input, approval, and routing of employee timesheets	Business system requirements in progress. Identified need for software vendor evaluation.
Labor Cost Analysis	Automate the calculation and posting of labor costs	Evaluating options.

Requirements Management System Implementation and Integration

The Requirements Management System (RMS) documents external and internal requirements applicable to the MRI management and operating contract for the National Renewable Energy Laboratory, establishes line management accountability for implementation, and is the primary method for conveying requirements to workers through policies, procedures, and programs. The applicable requirements support the Laboratory's mission, adequately govern the subject areas, and enable the Laboratory to manage risks at an acceptable level. Policies and procedures establish parameters for work processes and address risk.

Through the monthly review of metrics, performance elements such as cycle time to complete impact analysis on FMC actions and prime contract modifications, numbers of requirements analyzed and policies and procedures issued, and customer usage of the Policy and Procedure Website are tracked and analyzed. This review provides an ongoing forum to address performance improvement challenges and opportunities. Additionally, the Requirements Management System steward meets regularly with the DOE Contracting Officer to discuss performance results.

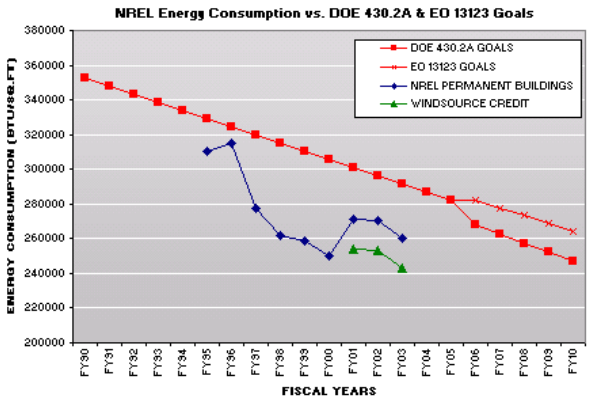
Special clause H-20, Application of DOE Contractor Requirements Documents, accepted by MRI in July 2003, provides specific criteria and guidance for the management and operating contractor to recommend to DOE administrative and operating requirements that adequately manage risk at NREL. In response to this clause NREL expeditiously designed and implemented a new process to tailor requirements and be compliant with this clause by the end of August 2003. NREL is institutionalizing this new process as a best practice. It documents accountability, requirements flow down, and the lifecycle of each operating and administrative requirement.

NREL has benchmarked the RMS against PNNL's Standards-based Management System, which was recently identified as a best practice by the LOB. NREL has tailored its process to suit the way the Lab does business, and to operate an RMS process that is both cost efficient and effective for NREL's mission.

Walking the Talk

Commitment to walking the talk is a strong part of the culture at NREL, and is demonstrated by the Lab's performance. Progress is consistent with the FY03 Sustainable NREL Master Plan and the expectations of the eight objectives in the Performance Agreement for Energy Management were met or exceeded.

NREL completed the 25-Year General Development Vision which features sustainability as a focus. The long-term vision of this plan is to create a world-renowned, high-performance research center on South Table Mountain that showcases energy technology innovation and leadership and embraces the best in energy practices.



Green Power Purchase Continues. *NREL completed its third year of purchasing 10% of its annual electrical usage through the local utility's Windsource Program.*

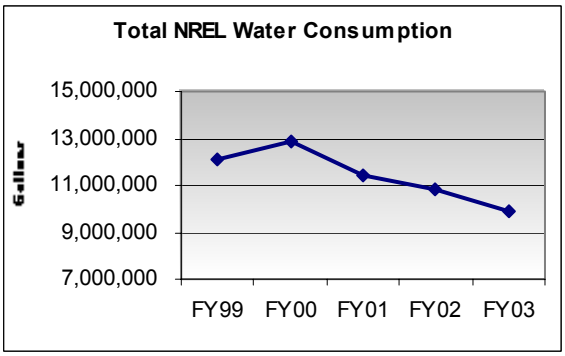
Departmental Energy Management Program (DEMP) awards were applied for and received for computer power management under the Model Program category and a natural gas fired boiler (fuel switching) at the National Wind Technology Center (NWTC) under the Project category.

NREL has made a significant investment in FY03 GPP projects that will reduce energy use. They include: 1) Energy efficient chiller – on track for completion by year-end; 2) Variable speed drives and heat exchangers at the Solar Energy Research Facility (SERF) – complete; and 3) Phase 1 of direct digital control (DDC) upgrades – on track for completion by 2004. Building occupant energy use program, featuring a computer power management program, will result in further energy use reductions.

Building-by-building current and historic monthly energy and water use information is now available to all staff on the Sustainable NREL Web site. This

building-by-building data is primarily derived from the NREL facility-wide site metering system. The centerpiece of the staff energy education program, a computer power management program, was initiated including completion of the Laboratory-wide baseline energy use and the implementation plan.

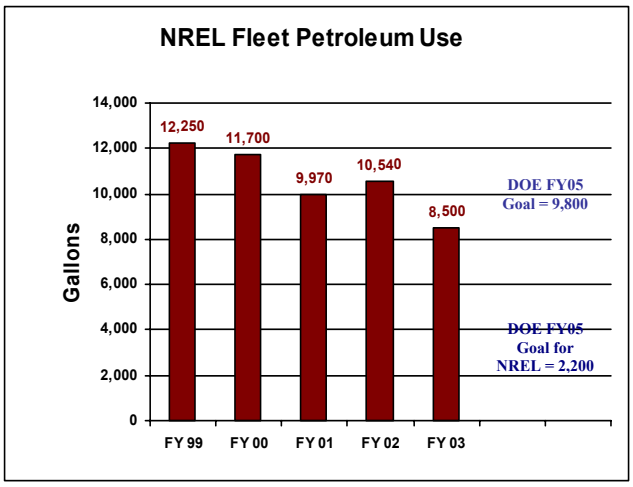
All of these activities help drive reductions in energy use at the Laboratory.



NREL exceeds 2004 federal water conservation requirements. *Four water conservation Best Management Practices (BMPs),as identified in the NREL Water Efficiency Plan, have been implemented at 100% of Laboratory facilities which exceeds the 2004 federal requirements of four BMPs at 15% of facilities. Three other BMPs are being evaluated for potential implementation in FY04/5.*

NREL received a 2003 Departmental Energy Management Award for outstanding achievement in energy and water management for the Sustainable NREL program. NREL sponsored a Technology Forum on Sustainable Management Systems (SMS). Approximately 70 participants including state, DOE, EPA, DOD, other laboratory and private sector representatives attended this daylong event.

The Alternative Fuel Vehicle fleet is effectively managed as demonstrated by the majority of performance goals being on track or exceeded. In FY03, NREL achieved the Executive Order 13149 goal of reducing fleet petroleum use to at or below 9,800 gallons by FY05. However, DOE's goal, specifically identified for NREL, will be much more of a challenge; requiring NREL to reduce petroleum consumption to at or below 2,200 gallons by FY05.



Federal transportation requirements met or exceeded. *NREL continued to meet or exceed all federal requirements in the acquisition of alternative fuel vehicles and the management of its fleet. Twenty of the NREL's 47-vehicle fleet are alternative fuel vehicles.*

CO 5.0 Environment, Safety, and Health - MRI will protect the safety and health of the NREL workforce, the community, and the environment.

NREL Proposed Grade: Outstanding

PO 5.1 Sustain excellence in safety, health, and environmental protection.

- PI 5.1.1 Proactive identification and correction of issues and problems (e.g., self-assessments, surveillances, etc.).
- PI 5.1.2 NREL's ES&H performance relative to agreed upon performance goals.
- PI 5.1.3 Outcomes and achievements that demonstrate effective ES&H management for the Lab.

Assessment Summary

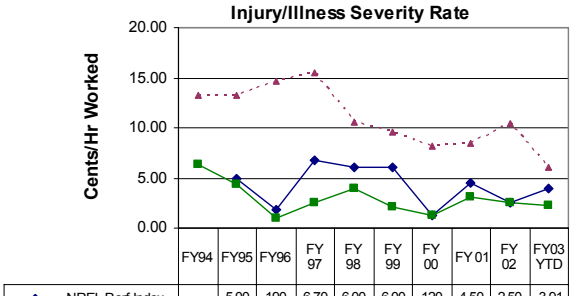
The Laboratory continued its very high level of ES&H performance as demonstrated by results against targets and baseline metrics, as well as by delivering more efficient and meaningful support services that minimize resource impacts. The latter includes multiple environmental management tools and products that were completed in a timely and cost-effective manner.

This level of performance was also validated through appraisals conducted by DOE-GO and NREL, with corrective actions and best-management process improvements implemented as appropriate. Laboratory management also demonstrated its leadership and commitment to ES&H by ensuring that all factors that detracted from the previous period's performance were corrected, these efforts including implementation of best-management practices.

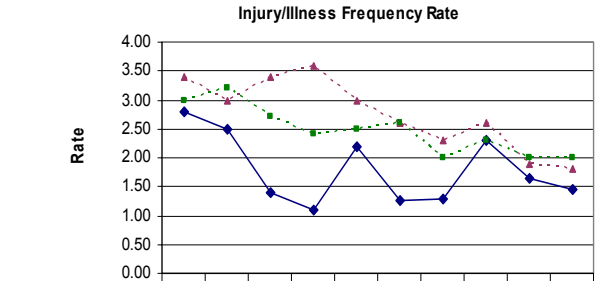
Contributing to, and supporting this high level of performance is a Laboratory culture that wholeheartedly embraces and practices the concepts of integrated safety management. This is particularly evidenced by NREL staff proactively incorporating ES&H in the earliest stages of project and facility design, and maintaining that focus through all phases of implementation and conduct of work. These characteristics will continue to be engendered across the Laboratory to ensure a sustained level of performance.

Performance Highlights

The Laboratory met or exceeded all ES&H performance goals as well as all applicable industry and DOE baseline metrics. Effective management of both the frequency and severity of injuries and illnesses are demonstrated in the following graphs. Safety Council, line management, and staff participation continues to be a critical element of this success story.



	FY94	FY95	FY96	FY 97	FY 98	FY 99	FY 00	FY 01	FY 02	FY03 YTD
NREL Perf Index		5.00	1.90	6.70	6.00	6.00	1.20	4.50	2.50	3.91
DOE Perf Index	13.20	13.20	14.70	15.50	10.60	9.60	8.20	8.50	10.44	6.11
NREL W.C. Costs	6.30	4.40	1.00	2.60	3.90	2.10	1.30	3.10	2.50	2.20



	FY94	FY95	FY96	FY 97	FY 98	FY 99	FY 00	FY 01	FY 02	FY03 YTD
NREL Rate	2.80	2.50	1.40	1.10	2.20	1.26	1.30	2.30	1.65	1.46
DOE R&D Rate	3.40	3.00	3.40	3.60	3.00	2.60	2.30	2.60	1.90	1.80
Inds R&D Rate	3.00	3.20	2.70	2.40	2.50	2.60	2.00	2.30	2.00	2.00

Environmental management processes and support function performance was enhanced through effective use of the new environmental staff position. These enhancements have increased support staff flexibility, improved timeliness of ES&S Office activities, and positioned the Laboratory for increased environmental activities.

Environmental Management

The South Table Mountain (STM) Site-Wide EA was completed and a FONSI issued. Process improvements reduced the project cost below the original $150K estimates, resulting in a final cost of $117K for the EA as well as two supplemental field studies. The EA represents a useful planning and management tool that compliments other planning documents developed by the Laboratory.

Coordination of the Environmental Management System (EMS) and *Sustainable NREL* continued through changes to the Annual Site Environmental Report that will facilitate future performance measurement under the Global Reporting Initiative, use of third-party subject-matter experts to improve objectives and metrics, pursuit of National Environmental Performance Track (NEPT) membership, and through process improvements to eliminate gaps and overlaps. These activities have strengthened the Laboratory position as a leader in both areas and will continue into FY04.

NREL continues to partner with DOE-GO to ensure proper NEPA assessments for technology deployment and demonstration projects across multiple program areas. A strong example is the I'SOT direct use geothermal project in Canby, California where NEPA concerns of multiple external agencies and organizations were successfully addressed in a very short time frame. The Lab will continue its focus on process improvement for enhanced timeliness and quality of NEPA actions.

Process Assessment and Improvement

NREL participated in DOE-GO Surveillances of the Waste Management and Minimization Program and Emergency Notification Processes, and simultaneously conducted two self-assessments of those programs. An NREL self-assessment was also conducted for the Radiation Safety Program. Third-party expertise was added to enhance the effectiveness of the Surveillance/Self-Assessment (S/SA) activities, where possible, and both efforts were considered to be very effective. The S/SA reports are being finalized and corrective actions and process improvements will be developed and implemented as appropriate. Beyond being an effective assessment and improvement tool the S/SA activities enhance the understanding of processes and coordination of work efforts between NREL and DOE-GO.

All corrective actions in response to the SERF hood fire were closed out. These efforts involved participation by staff in multiple organizations, as well as the Safety Council and Chemical Safety Panel. Several best-management practices were pursued within these activities to help ensure that all causal factors were identified and eliminated. The significant findings and best-management practices identified for this incident were shared with the DOE complex through the Lessons Learned server to contribute to, and improve complex-wide performance. Completion of these activities has successfully addressed deficiencies in the ES&H management system identified during the previous performance period.

Proactive Risk Management

NREL continues to implement risk assessment activities as a proactive management tool, resulting in effective control of hazards while reducing time and budget impacts. The STF Hazard Analysis Report and Fire Hazard Analysis were developed in parallel with the facility design process. This analysis resulted in incorporation of cost-effective design features having the buy-in of the local fire protection authority while effectively responding to the threat presented to high-valued research equipment. Additionally, Science and Technology center staff proactively identified potential ES&H issues and initiated necessary design and code reviews early in the design process for two major laboratory construction projects, thereby ensuring timely and effective management of ES&H risks.

PO 5.2 Identify and implement enhanced ES&H processes, practices, systems, and tools that enable the Laboratory to better meet its ES&H goals.

PI 5.2.1 Opportunities for enhancing NREL's ES&H management systems (e.g., ISM or sub-elements such as risk management, NEPA, and other environmental management processes) are identified and an action plan is established.

Assessment Summary

In addition to achieving a high level of performance, as described under Performance Objective 5.1, the Laboratory also strives to continuously improve its ES&H systems. External subject-matter experts are used to evaluate ES&H management systems against world-class standards and to validate those systems through certifications or other formal recognitions. The Laboratory took significant steps toward formal recognition of its environmental management system, with achievement of that recognition expected early in FY04.

When the Laboratory achieves a leadership role in ES&H, such as its successes in management of workplace injuries or sustainability and environmental management, it recognizes and acts upon its corporate responsibility to share the reasons for these successes with DOE and private industry. NREL and DOE-GO staff have jointly presented these success stories through various forums , and will continue to pursue appropriate communication venues in the future.

In coordination with DOE-GO, the Laboratory has pursued integration of its ES&H systems with those of a major EERE program. This effort to be even more involved in the earliest phases of project planning should prove extremely effective and beneficial for NREL, EERE, and for DOE as a whole.

Performance Highlights

Third Party Assessment and Recognition

Third-party assessment of high-level ES&H programs is being pursued through external recognition of the Environmental Management System (EMS). After evaluation of all available external certifications and recognitions the EPA National Environmental Performance Track (NEPT) was identified as the most appropriate and beneficial form of recognition for NREL. An NEPT membership application is being submitted, and pursuit of this recognition will provide multiple benefits to the EMS and Sustainable NREL. These include strengthening the Laboratory role as a leader in environmental management and sustainability; further improving the internal coordination of the two activities; and providing opportunities for deployment of EERE technologies. These activities will continue into FY04.

Support of DOE Complex Performance

NREL performance successes and lessons learned were communicated across the DOE complex through presentations at multiple DOE-sponsored workshops; direct involvement in quarterly briefings with EERE senior management; and use of the DOE Lessons Learned server. These activities strongly support the ISM concept of communicating information to all audiences that may benefit, and will continue to be pursued to demonstrate the Laboratory leadership role in ES&H arenas.

Proactive ES&H Integration

Numerous cross-organization efforts were completed by NREL and DOE-GO to help ensure that ES&H is properly integrated at all levels of the hydrogen program, and that NREL support services are properly aligned with headquarters element activities and requirements. Taking integration efforts so far "upstream" will contribute to the overall success of this critical DOE program, and is indicative of the advanced level of integration of DOE and NREL's environmental and safety processes.

CO 6.0 Outreach and Stakeholder Relations - MRI will build strong and productive relationships and alliances with stakeholders, advance awareness and support of the DOE renewable energy and energy efficiency mission, and advance math, science, and technology education.

NREL Proposed Grade: Outstanding

PO 6.1 Promote awareness of DOE/EERE and NREL missions and technologies, and build relationships that support the strategic directions of the Lab.

- PI 6.1.1 Stakeholder relationships and networks are established, maintained, and enhanced in support of the DOE/NREL mission.
- PI 6.1.2 Opportunities for enhancing institutional visibility and reputation are created and implemented.
- PI 6.1.3 Quality communications products are developed and recognized as supporting the advancement of NREL goals.

Assessment Summary

NREL's performance in public outreach and communications was exceptional during this period. Two key goals – increasing awareness of the DOE/EE and NREL missions and gaining significant visibility for DOE and the Laboratory along Colorado's front-range – were met with notable results. For example, the growing success of NREL's Colorado Executive Outreach (CEO) program brought new business and government leaders to the Laboratory to build personal networks and develop key alliances.

The media outreach strategy developed during the last period was implemented with striking results in terms of national visibility for DOE and NREL, especially as evidenced by the unprecedented media coverage of DOE's American Solar Challenge.

Initiatives to build working relationships with key media and public policy stakeholders continued to show significant results. On several occasions, national public figures that had previously visited the Laboratory extolled the Laboratory's work in public venues and in the media. National visibility for DOE and NREL also grew dramatically as the Laboratory built new, and nurtured existing, relationships with leading journalists and capitalized on national "issues in the news" to gain recognition for energy efficiency and renewable energy technologies.

In the communications area, NREL continued to make significant technical contributions to EERE's development and integration of a cohesive and consistent corporate image. NREL amplified the new EERE Web standards and guidelines developed in the last reporting period to meet new requirements. The Laboratory's communications products continued to enjoy significant recognition in the professional communications community winning several awards during the period.

Highlights

Stakeholder Relationship Building Shows Substantial Results

NREL's focus during the period was to connect DOE/NREL research and development programs and personnel with international, national, and regional stakeholders, and to build new corporate relationships that advance the DOE/NREL mission. Stakeholder partnership outreach significantly expanded opportunities to work with new stakeholders on programs that resulted in moving EERE technologies to the forefront in several areas.

Internationally … NREL's work with the Colorado International Trade Office has led to a relationship with the United Kingdom's Consulate General in Denver. By encouraging a series of visits to the

Laboratory by the Consular General, the British Embassy, Invest UK and AEA Technologies, the Laboratory stimulated talks about a joint research initiative on renewable energy under a DOE/UK Department of Trade and Industry Memorandum of Understanding (MOU). Forging such partnerships enhances DOE/NREL's international reputation as leaders in EERE technology development.

Nationally… NREL leveraged national conferences in Colorado to increase DOE/NREL's visibility among national stakeholders, providing them the opportunity to learn about the Laboratory and giving them tools for implementation of EERE policies and projects. As an exhibitor at the U.S. Conference of Mayors annual meeting in Denver, NREL made contacts with various city officials to provide information about alternative vehicle fleets. NREL also enhanced its relationship with the mayor of Freemont, Calif., who chairs the Mayors' Energy & Environment Committee, by hosting a visit for him to the National Wind Technology Center. This relationship is expected to provide NREL the chance to participate in next year's national conference.

The Laboratory hosted 50 state utility commissioners and staff of the Energy & Environment Committee of the National Association of Regulatory Utility Commissioners (NARUC) for briefings during NARUC's 2003 summer meeting. Not only did a tour of the Distributed Energy Test Site and the National Wind Technology Center familiarize high-level Federal Energy Regulatory Commission staff and utility commissioners with EERE research, it immediately resulted in one commissioner initiating a major wind power event for regulators, legislators, and industry leaders to move her state toward more aggressive adoption of wind energy. To reach a new national stakeholder group, NREL offered a mobile workshop to public and private sector land use planning professionals attending the 2003 American Planning Association National Conference. The workshop gave them a first-time look at energy efficient land use and covered key energy issues.

Regionally… By aligning stakeholder outreach and DOE/NREL research program goals, NREL broadened existing stakeholder alliances in the region, building win-win relationships that increased NREL/EERE's visibility, promoted stakeholder initiatives, encouraged regional and local support for technology adoption and firmly established a foundation for future partnerships.

NREL conducted a Stakeholder Technology Forum in June to demonstrate the Laboratory's leadership and expertise in energy and environmental management systems. The forum brought together NREL energy efficiency and energy management researchers and more than 50 leaders from business, government, and environmental community -- including Ball Aerospace, Gateway Computer, ConocoPhillips, the University of Colorado, Colorado State University, the U.S. EPA, the Colorado Department of Public Health and Environment, and numerous local governments. The Forum offered stakeholders potential opportunities for collaboration. Feedback from participants ranked the Forum as the "best in state" on the subject of energy and environmental management.

Regional partnerships that encourage technology adoption and raise visibility for EERE technologies matured on two fronts. The Laboratory aggressively embraced an opportunity to work with Jefferson County, Colo., to use EERE technologies to mitigate threats of wildfires in the populated parts of the county. NREL helped organize and lead development of a partnership among DOE, NREL, Colorado, Jefferson County, other federal agencies, and private industry to conduct a feasibility study for a biomass energy facility for processing forest thinnings collected during regional wildfire mitigation activities. NREL will provide technical expertise and support to the County under the MOU. The Laboratory also took steps to work with the City of Lakewood, Colo., and developer Continuum Partners on the $500 million redevelopment of the 100-acre Villa Italia Shopping Center. Two meetings have identified opportunities to incorporate energy efficiency and renewable energy technologies in the city's redevelopment project.

NREL's Colorado Executive Outreach (CEO) program brought new business and government leaders to the Laboratory to build personal networks, increase awareness, discuss partnership opportunities, and develop key alliances. Six CEO visits this year have helped build a better understanding of DOE/NREL's value to the business community and regional economic development. Visits by John Hansen, Colorado's

Secretary of Technology; Ken Reif, Director of the Colorado Office of Consumer Council and Continuum Partners have resulted in either follow-up visits, opportunities to participate in state-hosted technology forums or partnership opportunities that raise awareness of EERE technologies.

NREL aggressively pursued opportunities to gain DOE/NREL visibility on the state level. The Laboratory was highly visible at Governor Bill Owens' Colorado Technology Summit in September – sponsoring a session about technology transfer that reached nearly 3,000 participants and featured Director Truly, and well as research in hydrogen and distributed energy. NREL staff worked with the Colorado Governor's Office, Denver Mayor's Office and Denver Metro Chamber of Commerce to help identify energy issues related to an economic development trade mission presented at regional events bioenergy, nanotechnology and brownfields redevelopment. NREL also sponsored the annual Colorado Renewable Energy Society Conference. These outreach activities continue to build NREL's value as a resource for Colorado industry and government leaders.

National Visibility Increased Through Media Outreach

National visibility for DOE and NREL climbed substantially as the Laboratory built new, and nurtured existing relationships with leading journalists, publicized DOE and NREL events to attract media attention, and capitalized on national "issues in the news" to gain recognition for energy efficiency and renewable energy technologies. Taking advantage of the national media's continuing focus on the President's hydrogen initiative, domestic energy supply issues and energy policy legislation, NREL's strategy to pitch news stories in the context of these national issues, offer expert spokespersons for media interviews and host media for Laboratory visits resulted in more than 600 published or broadcast news stories about EERE/NREL technologies during the six months. Readership penetration is estimated at 130 million for the printed newspaper stories.

For the year, the number of national news stories increased by more than 200% over FY 2002, reflecting the major success of NREL's strategic focus on working with national media to achieve broader visibility for DOE/EERE technologies. National stories included two NBC Nightly News stories featuring interviews with NREL experts as well as expert interviews in Time Magazine, the Boston Globe, and the New York Times. In September, NREL began working with PBS on a story for the *NewsHour with Jim Lehrer.*

The number of visits to the Laboratory by media also doubled for the year, with 79 writers or reporters coming to NREL for background briefings, news conferences and events, or to pursue specific news stories. In May, NREL hosted an all day energy seminar for participants of the University of Colorado's Scripps Howard environmental journalism program. Journalists also covered Secretary Abraham's July 1 news conference at NREL; the Denver rollout of a new fuel cell vehicle at the Laboratory; the DOE-sponsored "Drive to Survive" event; and the Nobel Laureate Distinguished Lecture with Dr. Richard Smalley. Successful coverage for each of these events was stimulated by DOE/NREL media advisories, phone calls, and story "pitching" and resulted in regional awareness of the Laboratory and its work for DOE.

NREL's outreach strategy to provide important publications with expert interviews resulted in the Laboratory placing its second "expert" on an erudite conference panel hosted by the highly esteemed Massachusetts Institute of Technology's (MIT) Technology Review Magazine. After media staff arranged several expert interviews for the magazine with NREL's John Turner, Dr. Turner was asked to serve on a panel, *Hydrogen Economy Realized,* at the Emerging Technologies Conference at MIT in September, along with the CEOs of GE and Dell Computers. Not only was DOE/NREL's visibility

raised among national technology leaders, it is significant that EERE technologies were given equal billing with leading technologies in all sectors.

DOE/EERE Visibility Boosted Through Support for GO on the American Solar Challenge

NREL assisted the Golden Field Office (GO) in gaining unprecedented national visibility for DOE during its American Solar Challenge (ASC) competition in July by staffing the cross-country solar car race, conducting media and community outreach, and setting up a significantly improved Web presence for the event.

Media outreach resulted in more than 1,400 newspaper, magazine, and Web site stories, including stories in S*ports Illustrated, Washington Post, Washington Times, Chicago Tribune, Chicago Sun-Times, Los Angeles Times, Long Island Newsday, USA Today, MSNBC, CNN Interactive, the BBC Online*, and many other major market U.S. newspapers. Particularly successful were two video uplinks that provided broadcast media with footage of the ASC start and finish events in Chicago and Los Angeles. Early in the race, several hundred television news stations picked up the uplinked video footage of the race start. By the end of the race, 515 television news stories in major media markets had aired, including multiple national stories on CNN and NBC's Today Show. The culmination of news coverage was a live segment about the race with NBC's Al Roker, which credited the U.S. Department of Energy for sponsoring the race. NREL also provided technical improvements to the ASC Web site that made it easier to use by media and the public. The Web site recorded 12 million hits. Particularly successful was a GO/NREL strategy to provide high quality news feature photographic images to the media, which resulted in photos in USA Today and on Yahoo!.com.

Informing and Educating National Leaders Reaps Greater DOE/NREL Recognition

Educating key policy makers and opinion leaders about the Laboratory and DOE/EERE technologies forged strong partnerships with influential national leaders and resulted in exceptional visibility for the shared DOE/NREL mission. Executive management seized opportunities to inform national leaders through a dynamic visitor program. The Lab hosted 26 visits during period for VIPs such as Energy Secretary Spencer Abraham, Energy Information Agency Chief Guy Caruso, National Center for Atmospheric Research Director Timothy Killeen, University Corporation for Applied Research President Richard Anthes, President and CEO of the Electric Power Research Institute Kurt Yeager, Dr. Hermann Scheer, president of Eurosolar and German parliament member; Nobel Laureate Dr. Richard Smalley, Senior Policy Analyst Tamara Jackson of the White House Office of Technology Policy, and corporate executives from several major companies including Volkswagen and UTC Power.

Such visits create appreciation of NREL's research, facilitate support for DOE/NREL, and are critical to the advancement and adoption of EERE technologies in national arenas. Of particular note, NREL hosted a two-day meeting of the Laboratory Operations Board of the Secretary of Energy Advisory Board at which executive management presented DOE/NREL technologies to this group of national business and government leaders. Subsequently, the Board's vice chair accepted a position on NREL's National Advisory Council.

The VIP Visitor Program's success was apparent as several policy makers "in the news" spoke about the DOE and Laboratory's work in public forums. Three national leaders who visited the Laboratory were quoted in Denver newspapers supporting the Laboratory's mission and EERE technologies. One was quoted in the Denver Post describing the Laboratory as "the future of energy in our nation;" another speaking at a natural gas forum, "lauded the Golden-based NREL and its research…" according to a Denver Post article; and yet another national figure in a Rocky Mountain News article supported the research at NREL.

NREL hosted the annual Congressional Staff Study Tour for the Office of Energy Efficiency and Renewable Energy, providing an in-depth education for staffers from the Senate Energy and Water Appropriations Subcommittee, the House Science Committee, the House Energy and Commerce Committee and the Office of Senator Wayne Allard. Interactions with federal government officials and state legislative staffers familiarized more than 90 opinion leaders with renewable energy and energy efficiency technologies.

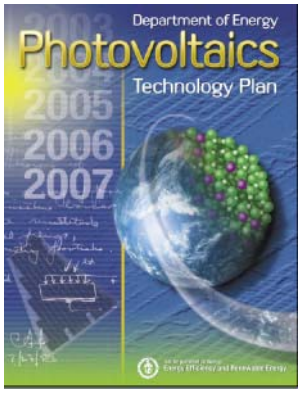
In collaboration with the University of Colorado and the Colorado School of Mines, the Laboratory provided technology briefings and tours for influential federal government officials, staffers for several key congressional committees and offices of four U.S. representatives and one senator. With the National Conference of State Legislatures, NREL conducted a "Renewable Energy Seminar" and lab tours for 40 state energy officials and legislators. These visits have led to repeat visits for more in-depth information that often have a meaningful impact on Laboratory operations and research.

NREL's Leading Edge Capabilities Advanced DOE/NREL Technical Communications

NREL stays on the leading edge of communications technologies to provide technical expertise and more efficiently produce high-quality communications products for the Laboratory's researchers and their programs.

NREL contributed to the production of two long-term, multi-year research plans. NREL's extensive knowledge of solar and hydrogen technologies and industries helped these programs more clearly present and articulate their ideas, increasing the effectiveness of these plans.

NREL played a major role in developing the 2003-2007 Multi-Year Technical Plan for the Solar Energy Technology Program. NREL wrote major portions of the content and strengthened the plan through services such as technical editing. This comprehensive document includes major chapters on solar energy; solar markets and applications; the systems-driven approach; specific technical discussions of photovoltaics, concentrating solar power, and solar heating and lighting; new solar concepts; and managing the Solar Program.



NREL also helped complete the draft Hydrogen, Fuel Cells & Infrastructure Technologies Program Multi-Year Research, Development, and Demonstration Plan by managing the production schedule and developing a tool to better manage the review process. In response to a request from the program, NREL enhanced the online version of the plan by developing a mechanism to collect and manage stakeholder feedback.

NREL developed many unique database applications. Databases greatly increase efficiency by using data entered once in several different applications.

The new Project Locations section of the Building America Web site is a prime example of how databases can help optimize productivity. This innovative section of the Web site, which NREL developed at the program's request, is populated by data from the Building America House Performance Database. When the database is updated by a Building America team, wherever the team is physically located, the project locations on the Web site are automatically updated with the same data. Databases allow subject matter experts to enter the data while the program maintains central control, a key feature. NREL used its thorough knowledge of building technologies to meet the program's goals.

The NREL.gov Web site redesign was also completed and sent live this reporting period. Easier access to information about the Lab's key technologies is one of the most significant improvements. The new site architecture increases the visibility and accessibility of NREL's research and development activities.

Now, users immediately see all the technologies and research areas with which the Laboratory is involved. This allows stakeholders to quickly find the information they need. NREL is converting the programs' existing Web sites to the new design.

NREL employed leading edge technologies to produce a comprehensive exhibit highlighting the 50th anniversary of the invention of the solar cell. The exhibit was extremely well-received at the 3rd World Conference on Photovoltaic Energy

Conversion held in Osaka, Japan, and it has proved to be an effective communications tool for the solar program in several additional venues. The exhibit highlights the first solar module ever constructed, significant pages from the inventors' actual lab notebooks, and a CD-ROM video presentation.

NREL Technical Knowledge and Expertise Enhanced Effective Implementation of EERE's New Communication Approach

NREL has a unique insight into the challenges and opportunities EERE and the programs face when delivering technical information and identifying appropriate audiences. This insight, which is a result of our communicators' strong relationships with the programs, allows NREL to formulate effective communications strategies that best meet EERE's needs.

NREL helped EERE develop and integrate a strong and cohesive corporate image. A major component of this effort was new EERE Web standards and guidelines, which NREL helped construct based on best practices and the Laboratory's understanding of EERE's communications and outreach goals. Furthermore, NREL understands the programs' goals, which helped the Laboratory apply the guidelines to the individual programs.

NREL led the effort to consolidate several individual consumer-focused Web sites into a single EERE consumer Web site. This site, "Energy Savers: A Consumer's Guide to Energy Efficiency and Renewable Energy," consolidates consumer data from program Web sites, the EERE clearinghouse, and the Energy Savers campaign into one easy-to-use site. Importantly, this new site helps advance Secretary Abraham's Smart Energy Use education campaign.

In support of DOE's Smart Energy Use Campaign, NREL quickly coordinated several updates to the Energy Savers campaign, which the Laboratory has managed since its inception. Secretary Abraham continually highlighted Energy Savers this reporting period and used the Web site as the cornerstone of his education outreach campaign addressing the nation's projected natural gas supply shortage. The Secretary has asked DOE, federal agencies, and all 50 governors to link to the Energy Savers Web site to further the reach of the campaign and help consumers understand what they can do to save energy.

Further strengthening the new EERE communications approach and design, NREL developed special print product templates, similar to those the Laboratory developed for the Web. At their request, NREL has completed template designs for the Industrial Technologies Program, the Federal Energy Management Program, and the Weatherization and Intergovernmental Program. One of the first documents NREL produced that incorporated the new EERE corporate look was the 75-page Rebuild America "Energy Smart Guide to Campus Cost Savings." Additionally, NREL developed the FEMP Style Guide, which was a priority for the FEMP director. This style guide will help strengthen FEMP's and EERE's consistent corporate presence.

A component of the new EERE communications strategy is to return the management of the Energy Efficiency and Renewable Energy Clearinghouse (EREC) to EERE. During this transition, NREL acted as a consultant to streamline the transition and minimize losses in productivity. Having managed the program for the past 10 years, NREL has a deep institutional knowledge of EREC. To ensure that knowledge was not lost, NREL transferred information and insights through issues papers, cost analyses, recommendations for future enhancements, and presentations to EERE staff.

Communications Awards Recognize Quality

NREL upheld its strong tradition producing high quality products, acknowledged by winning four communications industry awards this period. The International Association of Business Communicators recognized three NREL projects with awards, and two NREL projects won honorable mention in the National Association of Government Communicators competition. This brings NREL's communications awards total to 21 for the year. Peer recognition such as this confirms that NREL is providing quality technical communications expertise to EERE and the Laboratory's programs, is effectively advancing technology transfer, and is promoting EERE technologies.

PO 6.2 Demonstrate value as a corporate citizen within the local community.

PI 6.2.1 Opportunities for positive local community involvement and demonstration of good corporate citizenship are created and implemented.

PI 6.2.2 The Visitors Center is strengthened as a local community and DOE/NREL asset.

Assessment Summary

This performance period was marked by major successes in introducing DOE and NREL to new local stakeholders and in seeing an unparalleled number of visitors to the Laboratory. A community leaders breakfast at the National Wind Technology Center introduced more than 40 local business leaders and government officials to wind energy and DOE's/NREL's work.

An aggressive strategy to offer special events and better programming at the Visitors Center yielded a record number of visitors in FY 2003. More than 15,300 people – a 20% increase over FY 2002 -- participated in public programs. In June, the Center offered a two-day Consumer Energy Expo that drew more than 700 visitors – another record.

Highlights

Community Outreach Demonstrates Good Corporate Citizenry

Community outreach activities solidified NREL's reputation as a valued corporate citizen, raised visibility among new community leaders and boosted local support for the DOE/NREL mission. MRI, Battelle and Bechtel, continued to provide financial support to enable the Laboratory to actively participate in civic organizations and to implement programs of benefit to the local community.

NREL's dual strategy of inviting community leaders to the Laboratory and working in the community raised the Laboratory's visibility with new groups and familiarized community stakeholders with EERE technologies. A community leaders breakfast at the National Wind Technology Center introduced more than 40 local business leaders and government officials to wind energy and DOE's/NREL's work. Participants – including mayors or city council members from the cities of Boulder, Broomfield, Westminster, Erie, Lyons, and Superior -- represented a newly targeted audience on Colorado's Front Range who had no previous interaction with NREL. Representative Mark Udall whose district includes the National Wind Technology Center site, was the featured speaker.

A breakfast meeting at NREL's Visitors Center for Jefferson County Commissioners and key County management and economic development staff strengthened DOE's/NREL's relationship with these influential community leaders. Director Truly confirmed the Laboratory's willingness to work with the County in mutually productive areas, including the County's biomass initiative, which will use EERE biomass technologies to solve a community problem with wildfires. The meeting was particularly beneficial because it familiarized the permanent County staff with DOE/NREL, which should foster more lasting relationships with the County regardless of elected official turnover. As a result of this positive relationship, one of the commissioners arranged for a resolution to be issued by the National Association of Counties in support of the DOE/NREL mission.

NREL staff delivered 35 presentations to business and civic groups in the community, including speeches by executive management to the Colorado School of Mines' Young Environmental Forum, the Jefferson Economic Council's Nanotechnology Business Forum, and the Colorado Technology Summit. Director Truly briefed members of the Colorado General Assembly about the Laboratory's current activities, helping educate them about the latest developments in renewable energy. The briefing drew 16 legislators, including Colorado State Senator Moe Keller and Representative Ramey Johnson who represent the Laboratory's main campus. A growing relationship with Representative Johnson has led to opportunities to provide educational talks at one of her future town meetings.

Other relationship-building activities have increased the community's perception of the Laboratory as a valuable corporate citizen. Staff's participation in Jefferson County community planning meetings resulted in special consideration of the DOE/NREL site in County planning maps and greater public visibility for the open space easement DOE has

provided the community. NREL was invited to participate in an "Energy in the West" Forum at the University of Colorado, which resulted in a report that gave a more balanced view of the role of alternative energy in the West's future energy mix.

The Laboratory continued its work with chambers of commerce and other nonprofit agencies such as the Denver Urban League and Adelante Mujer with financial support from NREL's managing partners. The partners also funded 13 community service projects that were implemented this period as part of the *Community Crews* program that encourages employees to volunteer their time to a community project. Volunteers wear NREL "Community Crews" shirts and often are recognized in local newspapers. In addition, MRI and its integrated team of Battelle and Bechtel made the down payment on a Denver-area Habitat for Humanity home to be built by DOE/NREL employees in 2005. Not only will this community contribution confirm NREL's community commitment, it will showcase the value of renewable energy and energy efficiency technologies in community housing.

Visitors Center Outreach Draws Record Number of Visitors

An aggressive strategy to offer special events and better programming at the Visitors Center attracted more visitors in FY 2003. More than 15,300 people – a 20% increase over FY 2002 -- participated in public programs, VIP tours, educational activities, workshops, and special events. Of the record number of visitors, about 900 participated in tour programs and 4,200 in educational programs. The increased number of visitors indicates NREL's growing reputation in the community as a resource for consumer information and educational opportunities.

The Renewable Ranger education program was improved , with new lesson plans drawn up and the addition of hands-on demonstration kits to teach about renewable technologies. Of 150 teachers who were surveyed about their education experience at NREL's Visitors Center, 81% rated the educational value of the experience as excellent.

Improvements to the Visitors Center exhibit hall space have provided new flexibility. Creating a presentation area in the hall has made it possible to host larger groups for conferences and meetings, such as Stakeholder Forums, National Advisory Council meetings, the Laboratory Operations Board meeting, and a Middle School Science Bowl competition. It also makes it possible to host meetings while daily education programs continue, thereby expanding its capacity to handle visitors.

By far the most popular Visitors Center programs are consumer workshops and technology showcases. In June, the Center offered a two-day Consumer Energy Expo that drew more than 700 visitors. NREL filled 30 exhibit spaces with vendors who showcased energy efficient and renewable energy products and services. Feedback from both vendors and participants was positive. In conjunction with the Expo, DOE/NREL hosted a community meeting for neighbors, offering them an update on DOE/NREL activities and a private viewing of the Expo. A "Drive to Survive" event, showcasing hydrogen and alternative-fueled vehicles, attracted public interest and media attention.The Laboratory, in partnership with the Colorado Energy Science Center, also offered 22 workshops, which attracted a number of attendees.

PO 6.3 Implement programs that advance high-quality science, mathematics, and technology education.

- PI 6.3.1 Available resources are effectively utilized for conducting DOE's science, mathematics, and technology education programs, and for positioning NREL an as education leader.
- PI 6.3.2 Results of education evaluation tools and protocols indicate that NREL education programs are effectively conducted and meet or exceed DOE National Laboratory education program standards.

Assessment Summary

NREL's Education Programs benefited from vast programmatic growth, strategic partnerships and enhanced outreach, which has positioned NREL and DOE to take advantage of even greater opportunities in FY04. Increased EERE and NREL national visibility in the science education community is a positive outcome of leveraging significant external investments in the Laboratory's education programs. A substantial BP America

partnership with NREL has produced a Renewable Energy and Efficiency Education outreach vehicle providing a showcase of DOE/NREL research and technology to new, broader audiences.

In recognition of the Lab's education program management excellence, partners joined forces with NREL to deliver education outreach to greater numbers of students and educators than ever before. New fuel cell and hydrogen education workshops highlighted a continually evolving NREL/Colorado School of Mines collaboration reaching over 200 local and national middle school students and teachers. As a result of the exceptional program execution of the 2003 DOE National Middle School Science Bowl, DOE's Office of Science awarded NREL leadership of the 2004 National Middle School Science Bowl. This new responsibility will allow EERE and NREL to reach greater and more diverse audiences and provide yet another opportunity to take the EERE and NREL renewable energy and energy efficiency message across the nation.

Highlights

Expanded Opportunities Through Leveraged Partnerships and Outside Investments

NREL's partnership with BP America resulted in additional collaborations as the Renewable Energy and Efficiency Education on Wheels (RnE^2EW) bus and trailer were completed. RnE^2EW is designed to educate students, teachers, and the community in renewable energy and energy efficiency sciences and to showcase DOE/NREL research and technology. RnE^2EW now is poised to deliver renewable energy and energy efficiency messages to schools and communities around the country including high-profile national and international events such as the National Science Teacher's Association Conference and the World Renewable Energy Congress. This showcase of EERE technologies and research has been embraced and enhanced by additional partnerships.

Nationally, the Connecticut Clean Energy Fund has enhanced RnE^2EW through the sharing of ideas and development of curricula materials. The Colorado Governor's Office of Energy Management and Conservation has joined the RnE2EW partnership by creating a $10K renewable education materials award and promising future collaborations. Two of the largest Colorado school districts have begun to expand the role of fuel cells and renewable energy in their curricula and are preparing for professional development opportunities through RnE^2EW. Collaborations with the NREL National Bioenergy Center and the Electric and Hydrogen Technologies and Systems Center have developed hands-on, interactive renewable energy science education materials for students and teachers. RnE^2EW, coupled with partnership expansion, will deliver the EERE/NREL message to thousands annually.

New and Enhanced Education Programs Extend Reach to Diverse Populations

NREL was given the leadership for DOE's Office of Science National Middle School Science Bowl held in June, sponsored by General Motors (GM) and DOE. Sixteen diverse regional Middle School teams and teacher coaches came to the Colorado School of Mines campus for a two and one-half day "brain bowl" competition and model solar car challenge, which was highlighted in the August 2003 issue of *DOE This Month*. DOE and NREL staff presented new hydrogen fuel cell technologies to educators and team coordinators promoting the effective incorporation of hydrogen into science education. In preparation for a Hydrogen future, hydrogen fuel cell model cars will replace the solar cars in the 2004 competition in which over 20 national teams will compete.

The growing investment in the Laboratory's education programs by the Office of Science and General Motors, as noted in the National Middle School Science Bowl, reflects recognition of NREL's outstanding performance in pre-college programs, assists the Lab in serving diverse populations, and continues to raise the national profile of DOE and the Laboratory.

Promoting women in science, NREL co-sponsored the Colorado School of Mine's (CSM) *Women In Science, Engineering, and Math (WISEM)*

programs, including the *Women's History Month* workshop. Dr. Magda King, renowned scientist and mountain climber, inspired and challenged the nearly 200 female CSM students, NREL female researchers and engineers and others at this workshop. NREL and Colorado School of Mines successfully partnered to encourage women and minorities to pursue careers in science and engineering, supporting our goals of fostering a more diverse workforce for DOE and NREL.

NREL Surpassed Expectations for National Visibility in Science Education

Program evaluations for DOE's Office of Science-sponsored internship programs demonstrate that NREL continues to exceed Office of Science and Laboratory education expectations. The summer of 2003 boasted a 54% increase in interns hosted at the Laboratory. A 20% increase in funding by DOE's Office of Science coupled with program support from EERE allowed NREL to meet the greater demand for interns and resulted in more intern appointments. With greater intern requests for next summer, NREL has developed partnerships to support program growth and secure additional funded interns for 2004. Initial work with NASA has resulted in the future placement of four NASA - funded interns at NREL. Continued partnering with the Office of Minority Economic Programs will result in the additional placement of 10 funded interns in 2004.

NREL interns work hand-in-hand with top research scientist and engineer mentors. Together they work on the development of new technologies and research breakthroughs in renewable energy. At summers end, the interns present professional research papers to their peers and the NREL scientific community. In addition, teacher researchers develop education modules for their classrooms. Some interns co-author with their mentors and present research findings in juried scientific journals. These internship opportunities further expand DOE/NREL's national visibility and partnership opportunities as students and teachers return to their schools and universities throughout the nation.

Further enrichment of NREL's visibility among students, educators and parents included the National Middle School Science Bowl which provided an opportunity for more than 200 middle school students, teachers, sponsors, and parents to learn about NREL research and to participate in hands-on renewable energy experiments at NREL's Visitors Center. Also, the National Energy Education Development (NEED) conference brought more than 50 teachers from across the nation to NREL's Visitors Center for a half day of science teacher professional development in renewable energy delivered by Office of Education staff and NREL researchers.

NREL leveraged the Laboratory's nationally profiled Education Advisory Council (EAC) to increase recruitment efforts for African American, Native American and Hispanic students through the Society for the Advancement of Chicanos and Native Americans (SACNAS) and Mathematics, Engineering, Science Achievement (MESA) USA. NREL has successfully recruited a NASA representative to the EAC Board. Partnering with NASA and others will provide future educational opportunities and increased visibility for NREL's education programs as the Council provides guidance for programmatic efficiencies and education partnerships.

Board service places NREL in the forefront of science education leadership as staff represents NREL in many professional organizations (i.e. nationally; Triangle Coalition, National Science Education Leadership, statewide; Solar energy International, Colorado Science Educators network, Colorado Association for Minority Partnerships). Professional membership and participation allows for the exchange of science, mathematics and technology education information and the knowledge of and opportunity to impact educational issues such as No Child Left Behind. Keeping a pulse on national educational issues allows NREL to develop educational programs that meet educational standards and needs.